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Gruner et al.

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(54) ELECTROMAGNETIC RELAY ASSEMBLY

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Related U.S. Application Data

(63) Continuation-in-part of application No. 11/888,519, filed on Aug. 1, 2007.

(51) **Int. Cl.**
H01H 51/22 (2006.01)
H01H 3/00 (2006.01)

(52) **U.S. Cl.** **335/78**; 335/185

(58) **Field of Classification Search** 335/78, 335/83, 185
See application file for complete search history.

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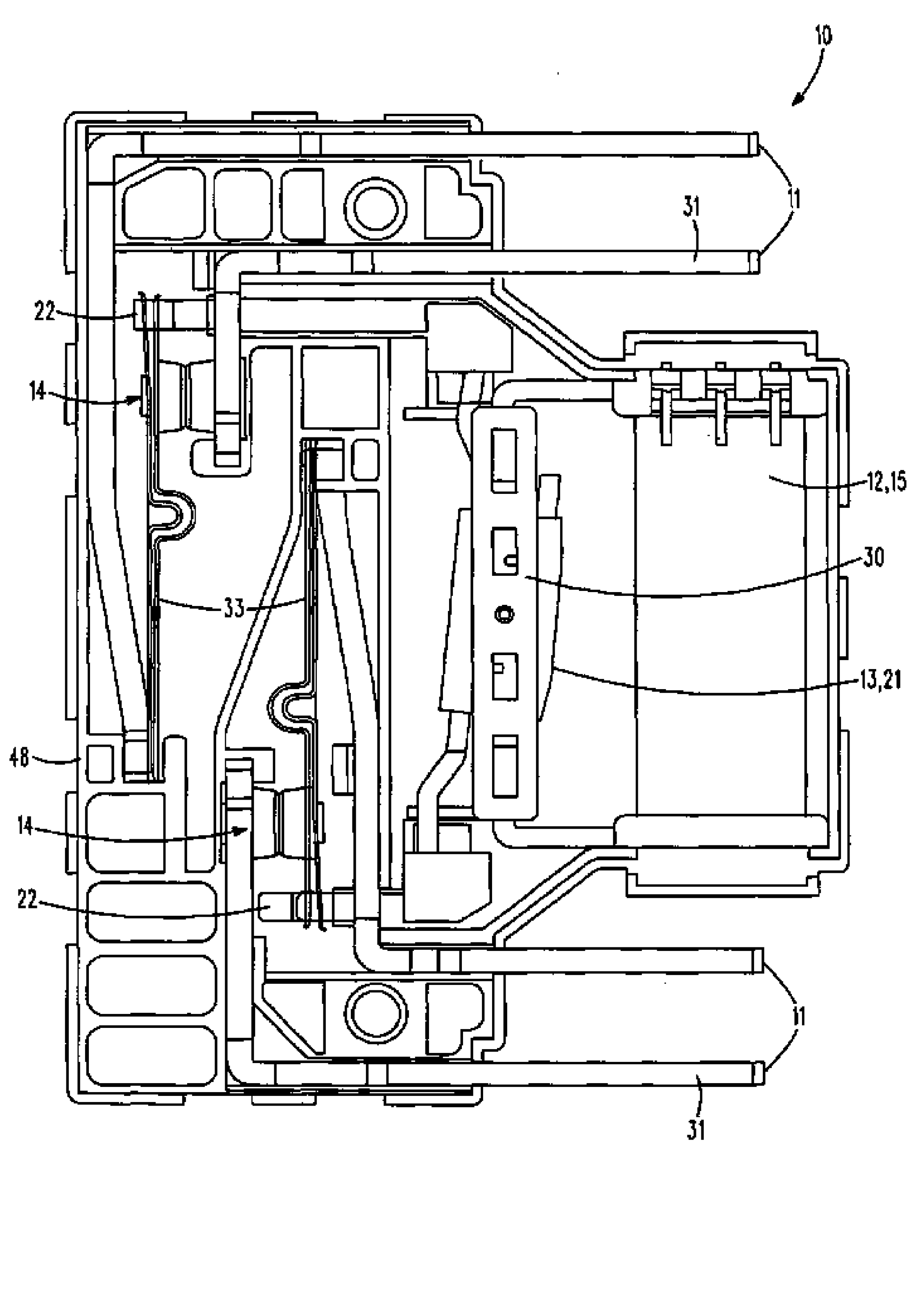
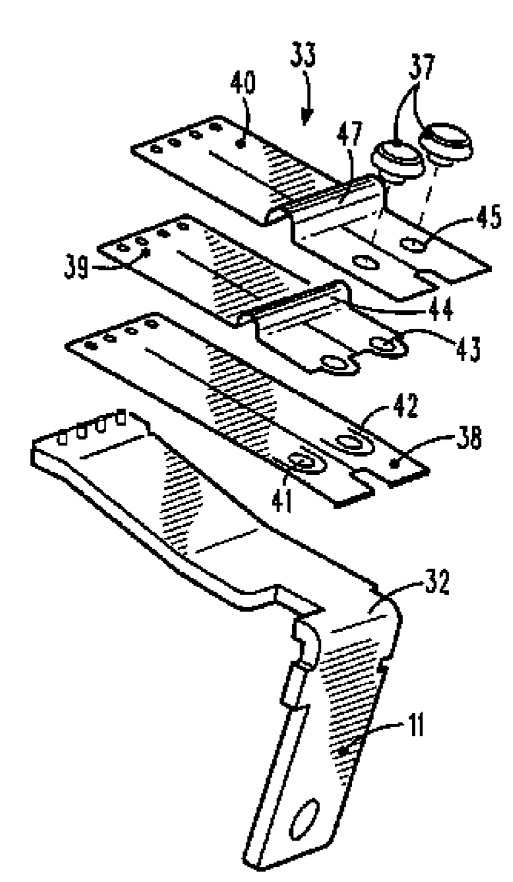
(57) **ABSTRACT**

An electromagnetic relay enables current to pass through switch termini and comprises a coil assembly, a rotor or bridge assembly, and opposing, balanced switch assemblies. The coil assembly comprises a coil and a C-shaped core. The coil is wound round a coil axis extending through the core. The core comprises core termini parallel to the coil axis. The bridge assembly comprises a bridge and a pair of actuators. The bridge comprises medial, lateral, and transverse field pathways. The actuators extend laterally from the lateral field pathway. The core termini are coplanar with the axis of rotation and received intermediate the medial and lateral field pathways. The actuators are cooperable with the switch assemblies. The coil creates a magnetic field directable through the bridge assembly via the core termini for imparting bridge rotation about the axis of rotation. The bridge rotation displaces the actuators for opening and closing the switch assemblies.

23 Claims, 17 Drawing Sheets





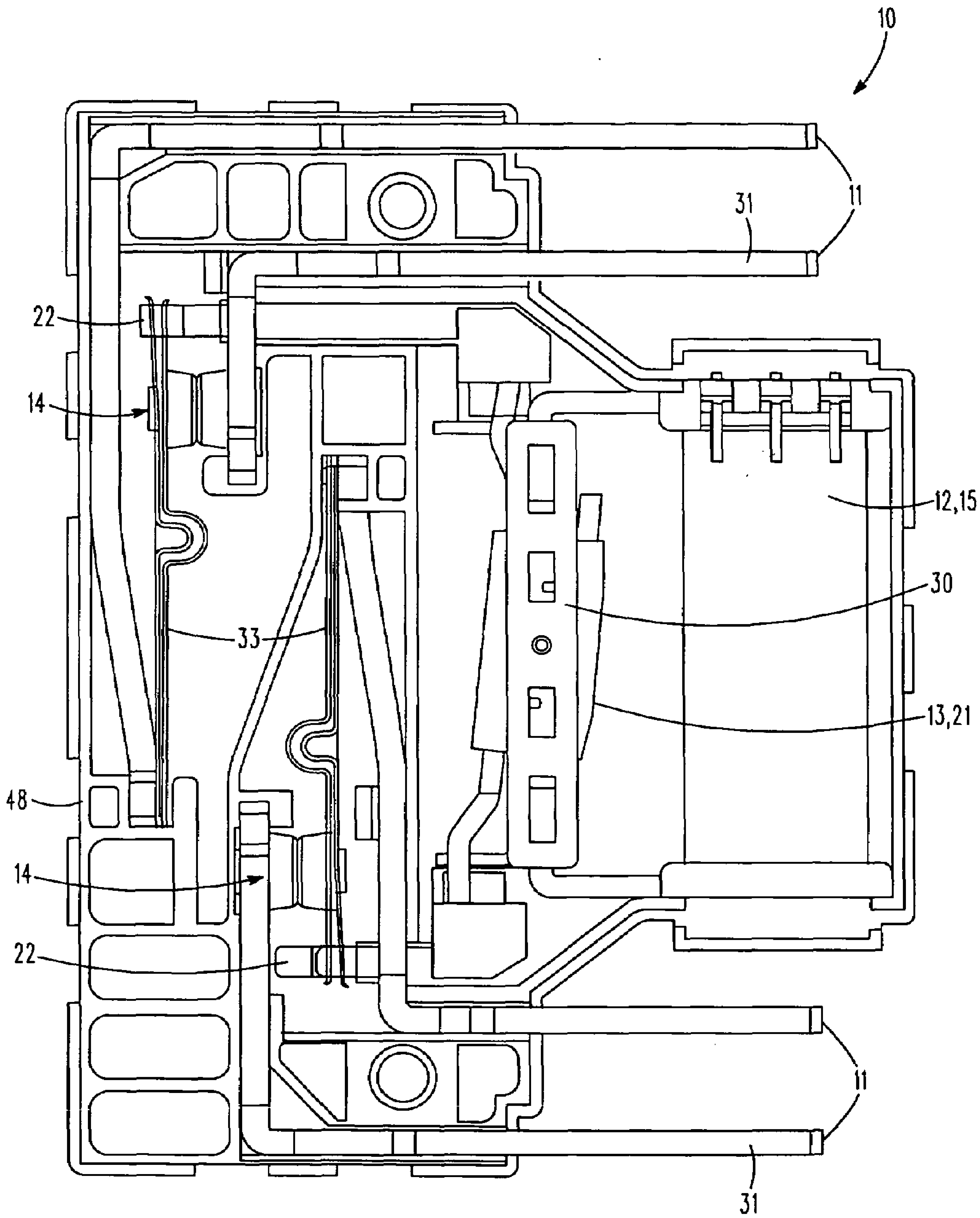


FIG. 1

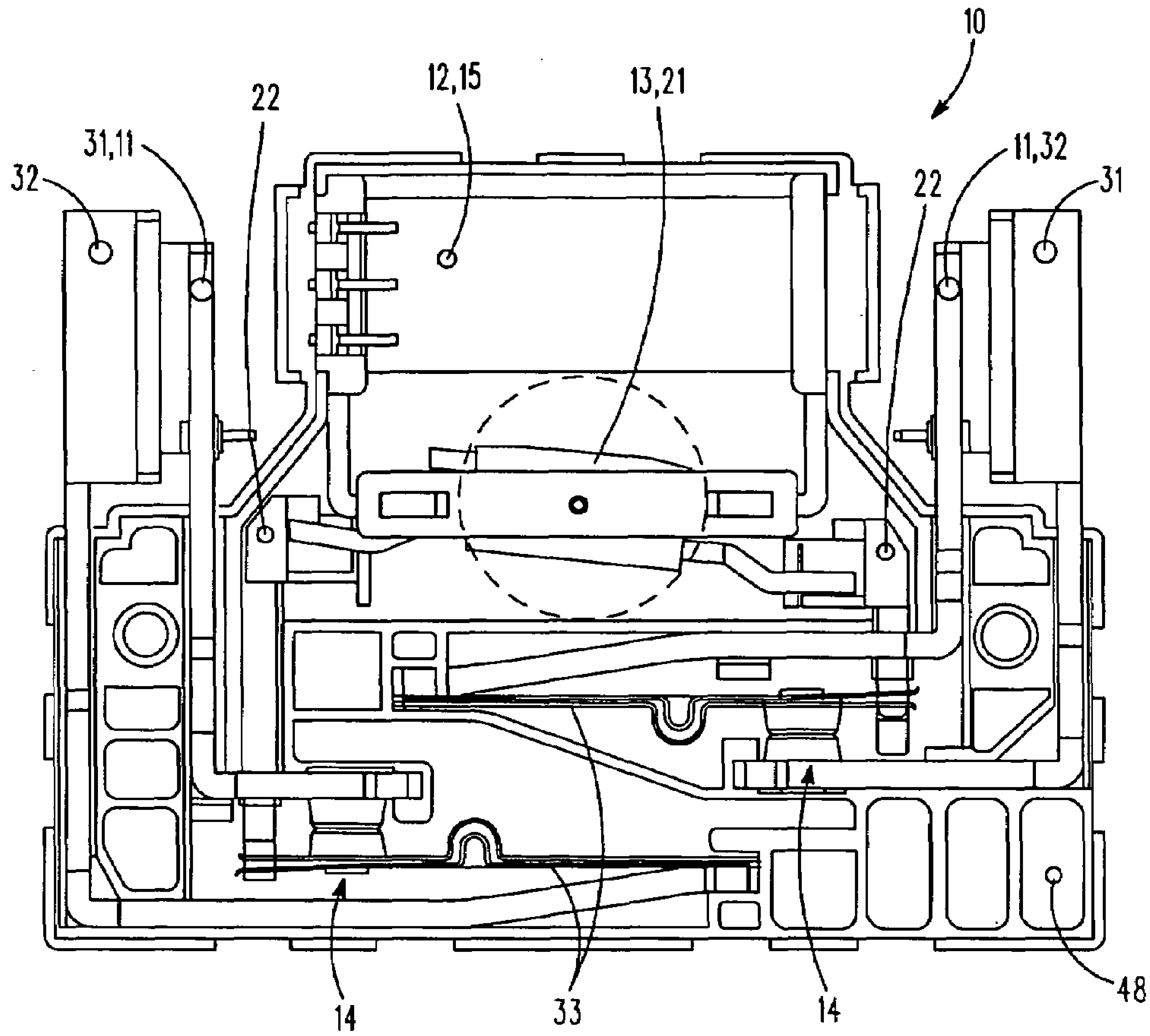


FIG. 2

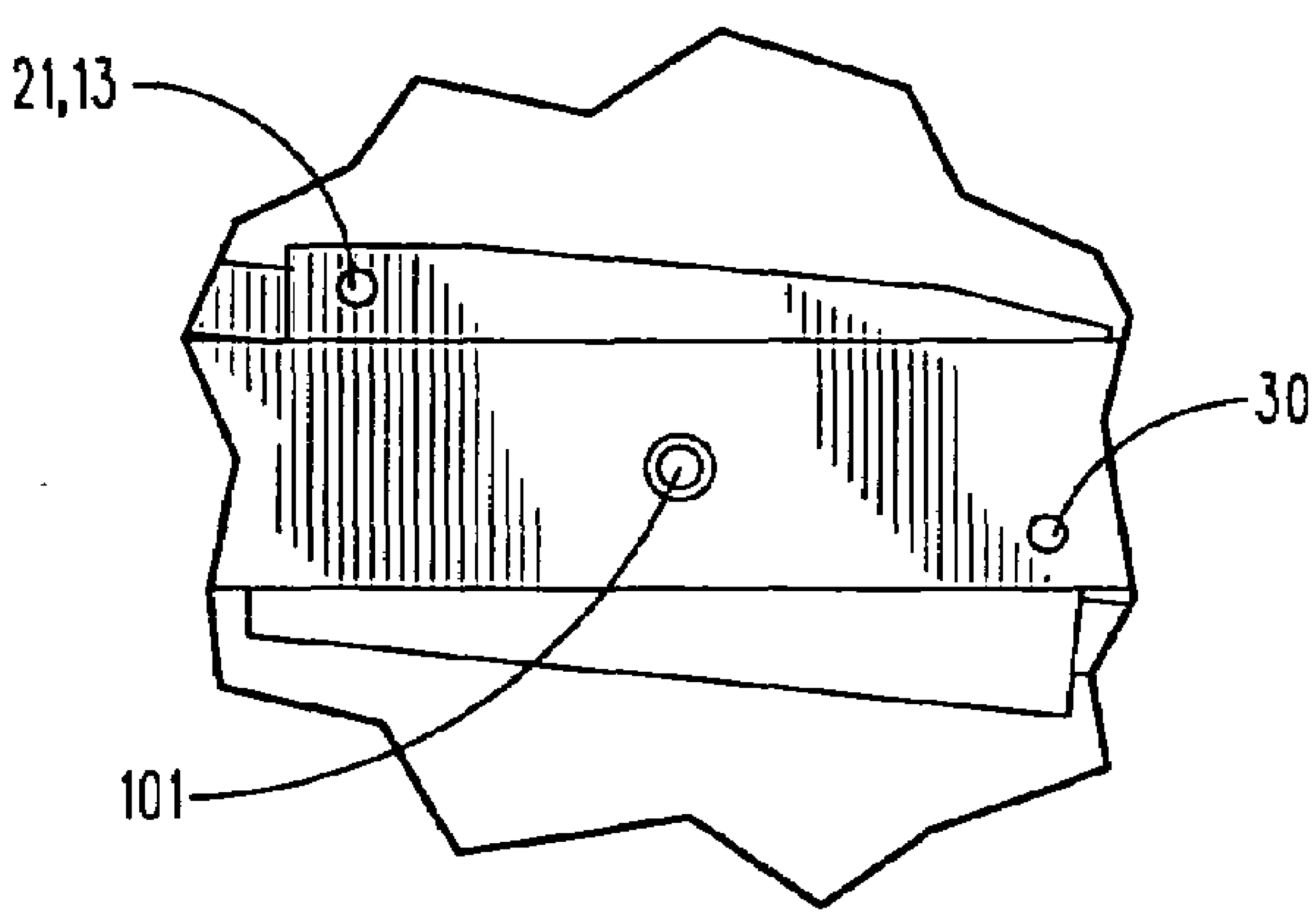


FIG. 2(a)

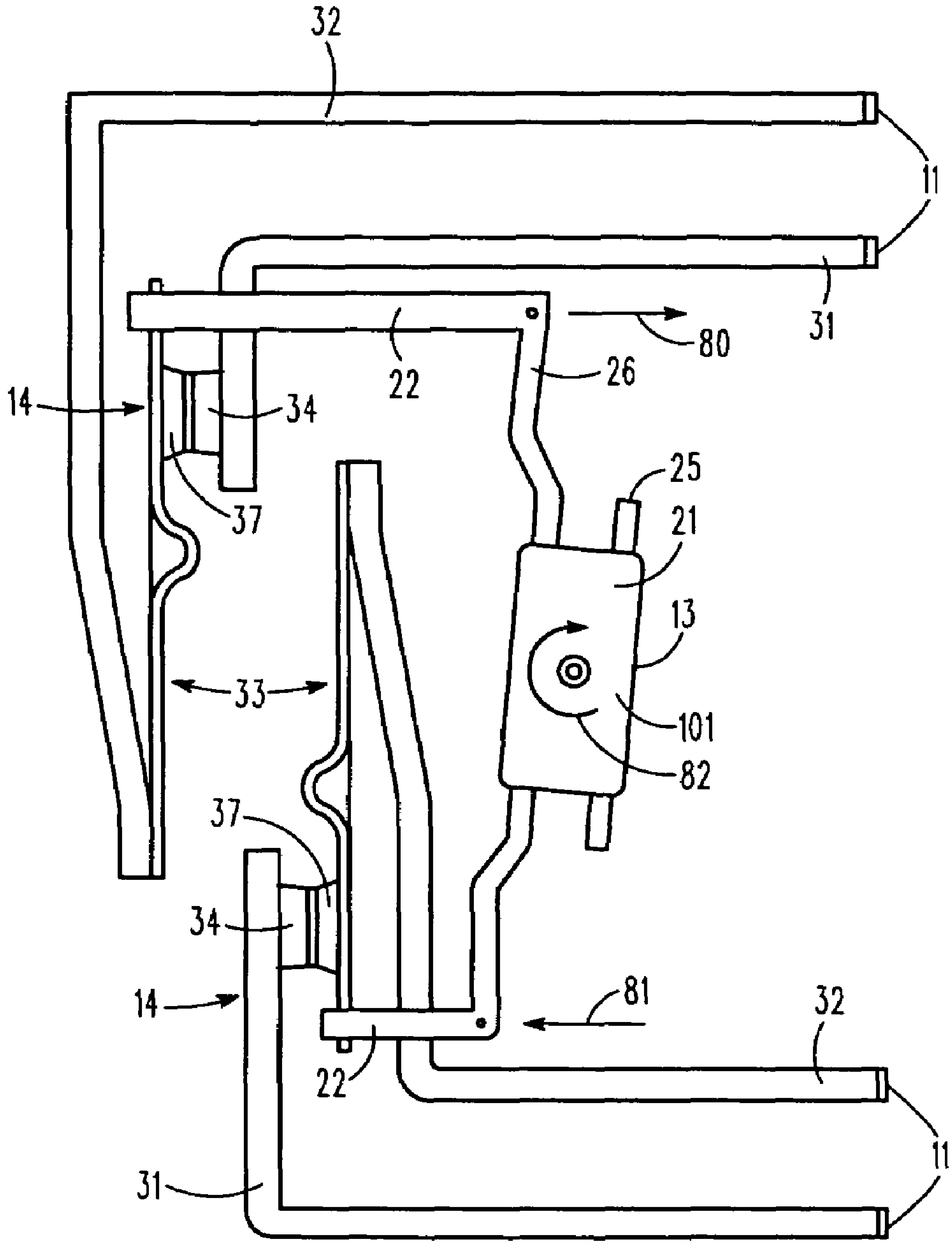


FIG. 3

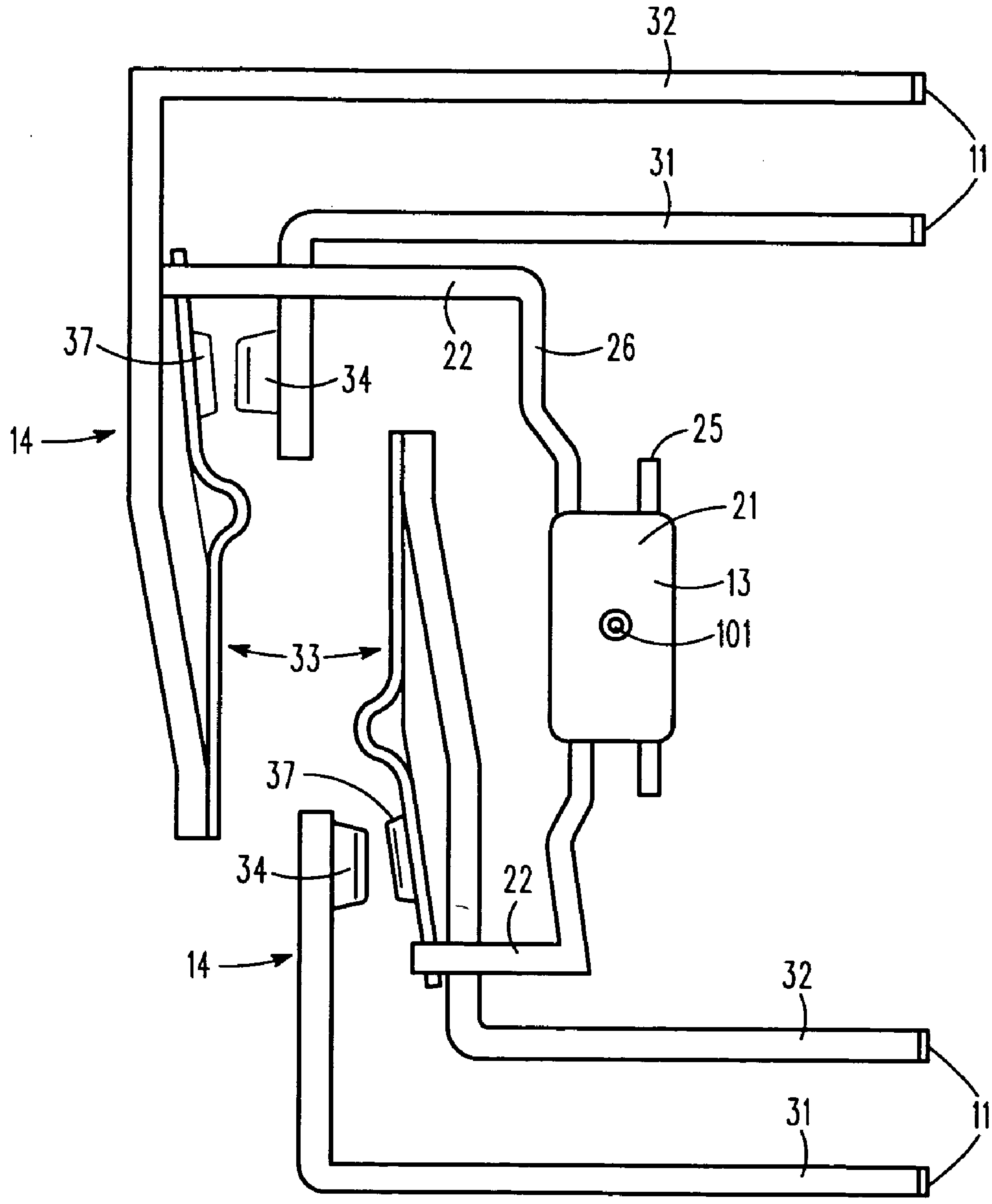


FIG. 4

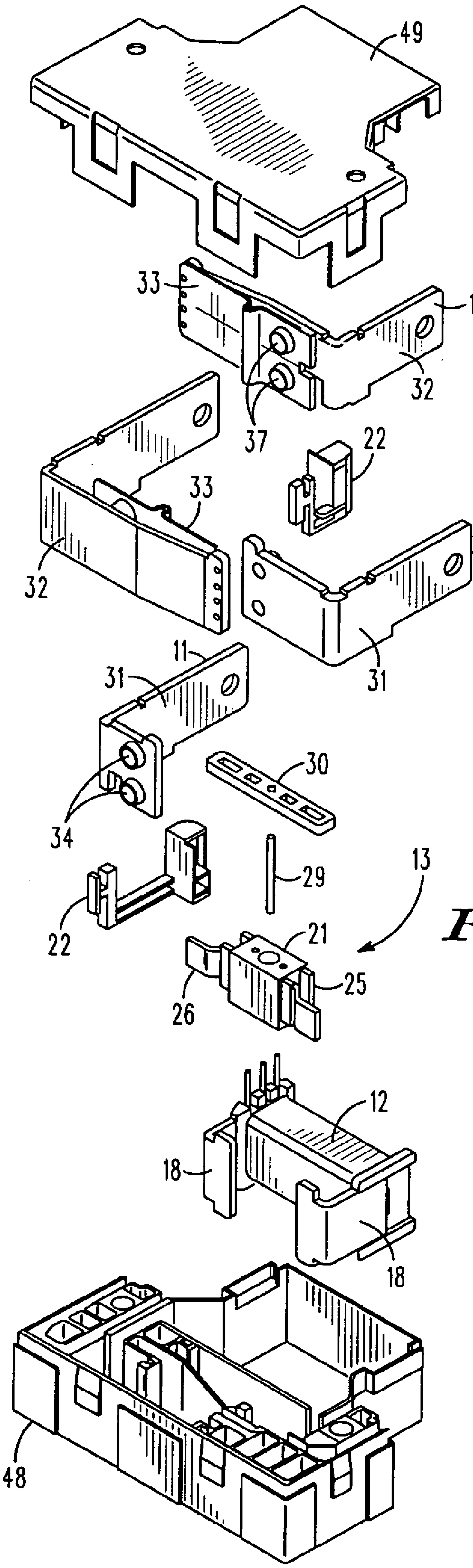

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FIG. 5

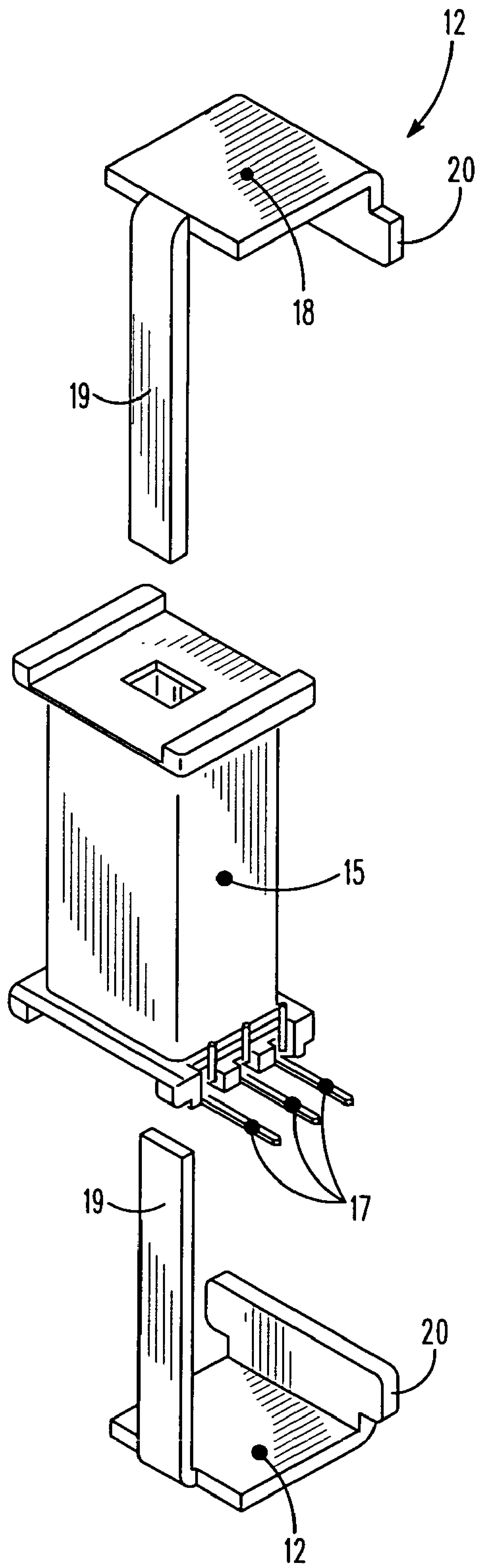


FIG. 6

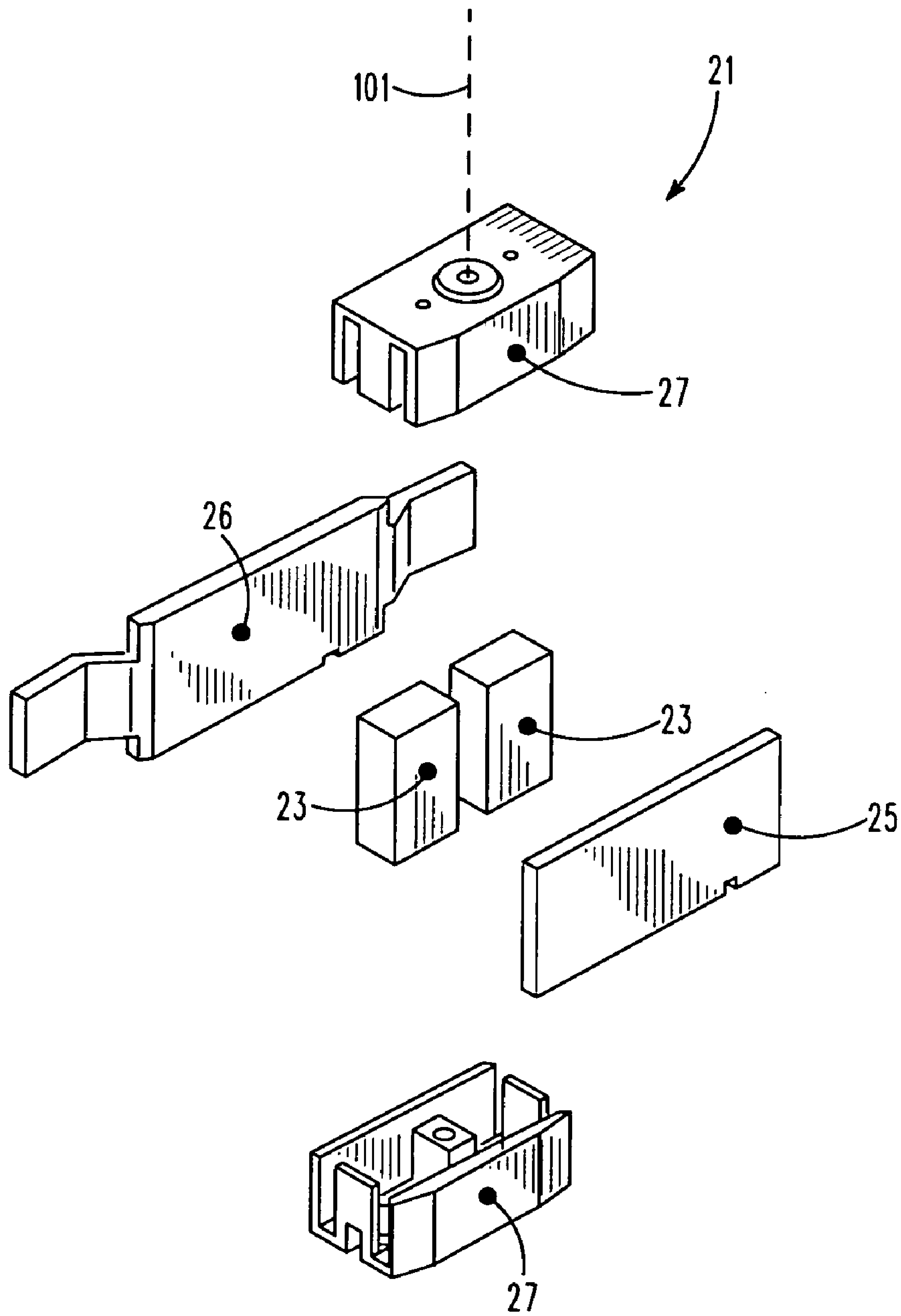


FIG. 7

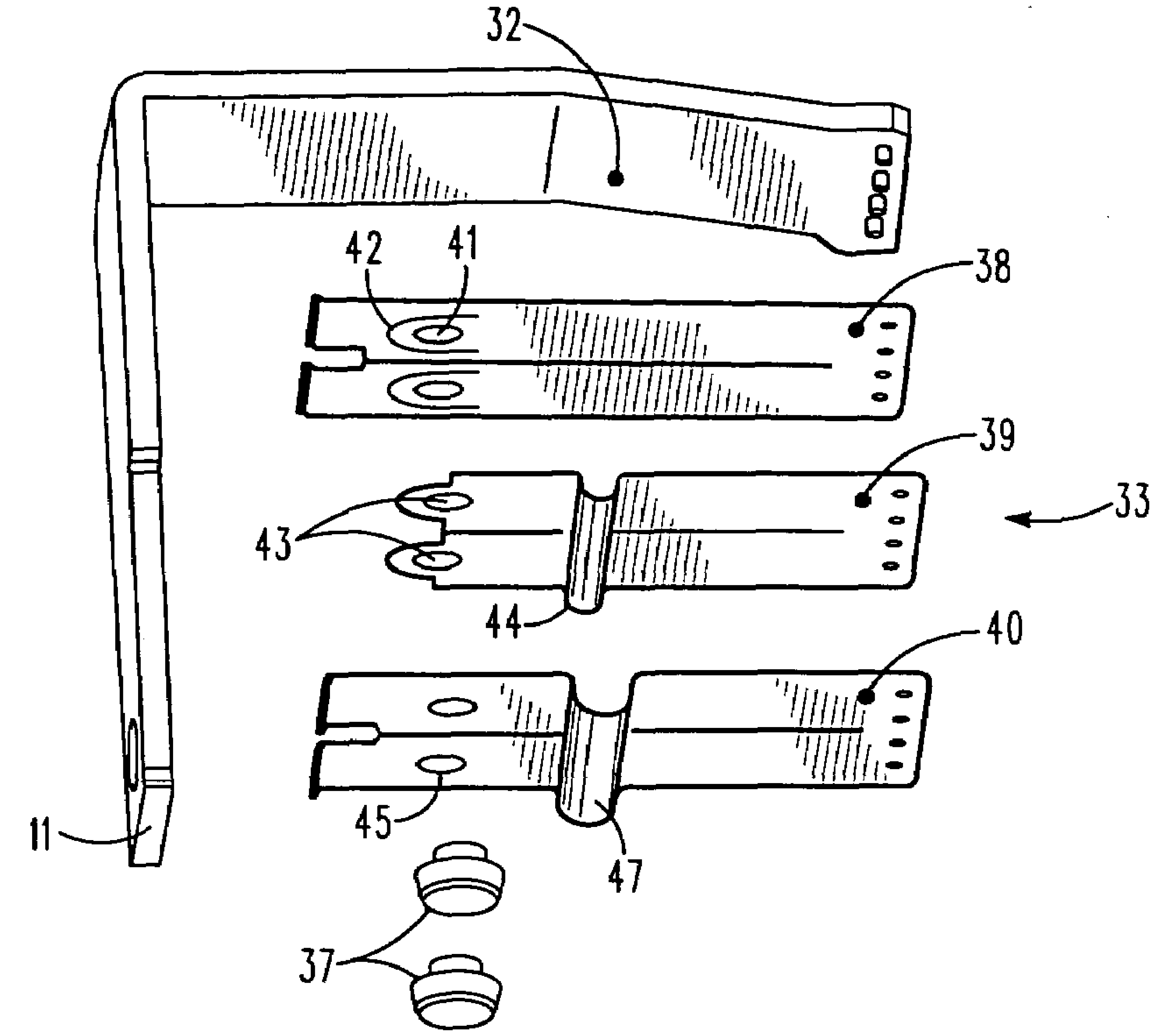


FIG. 8

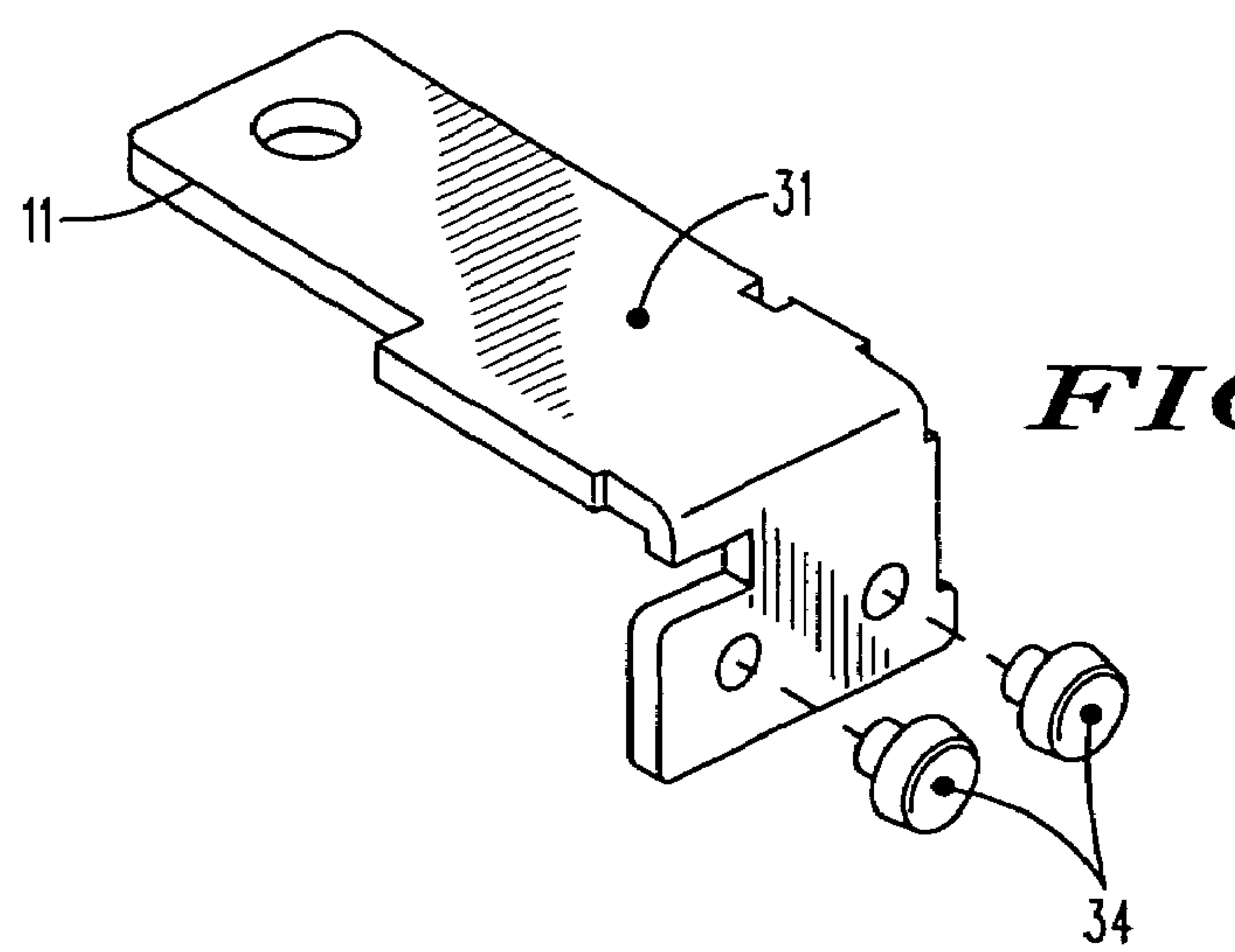


FIG. 9

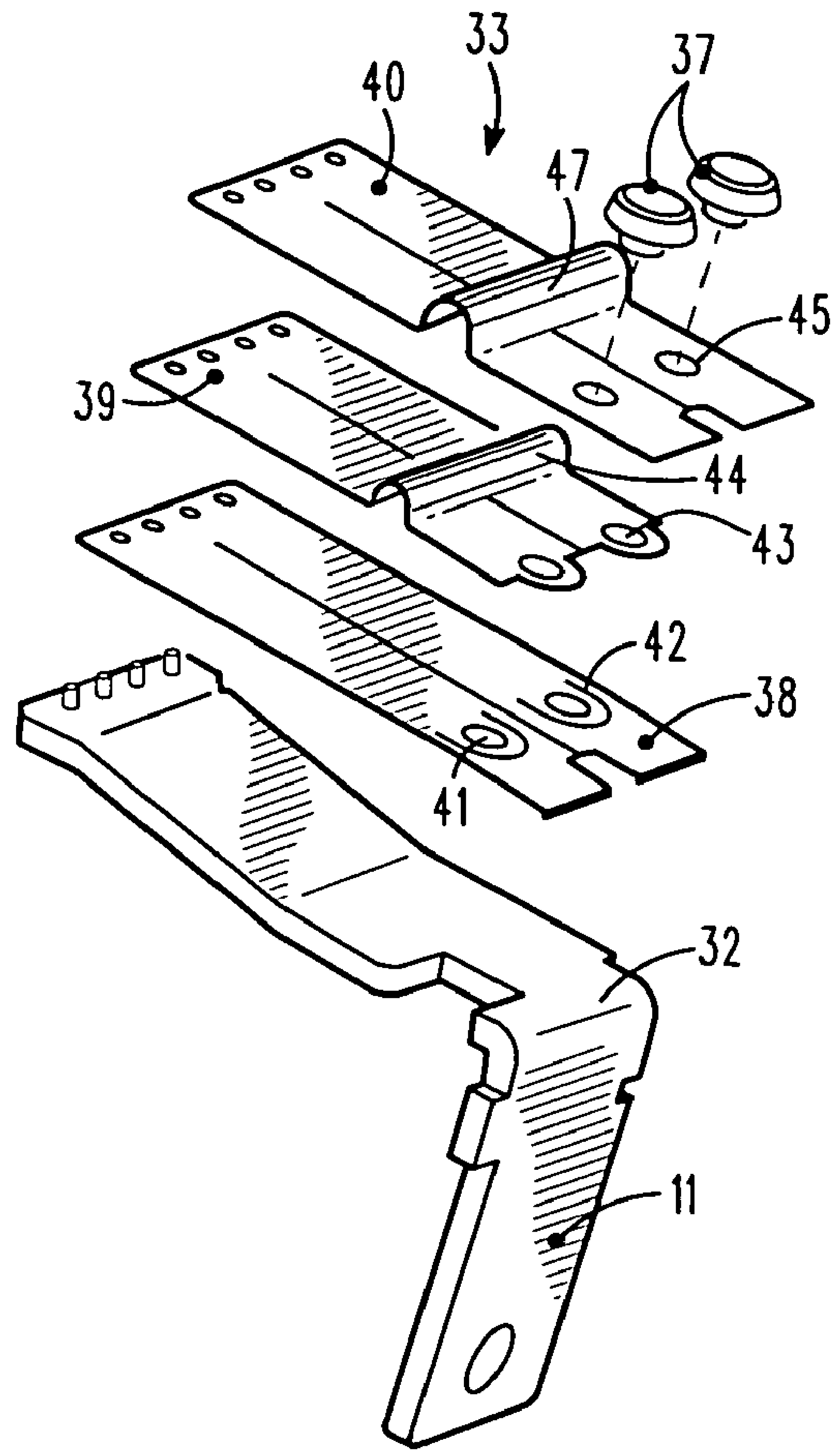


FIG. 10

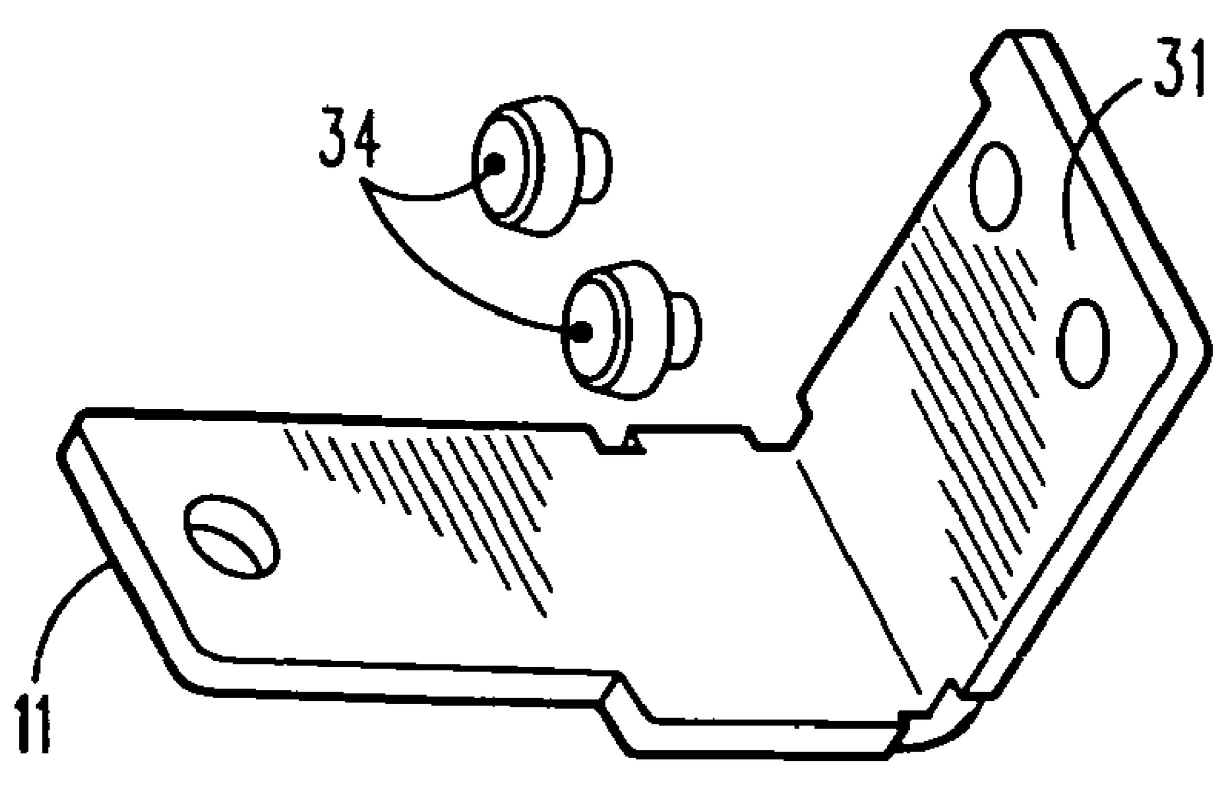


FIG. 11

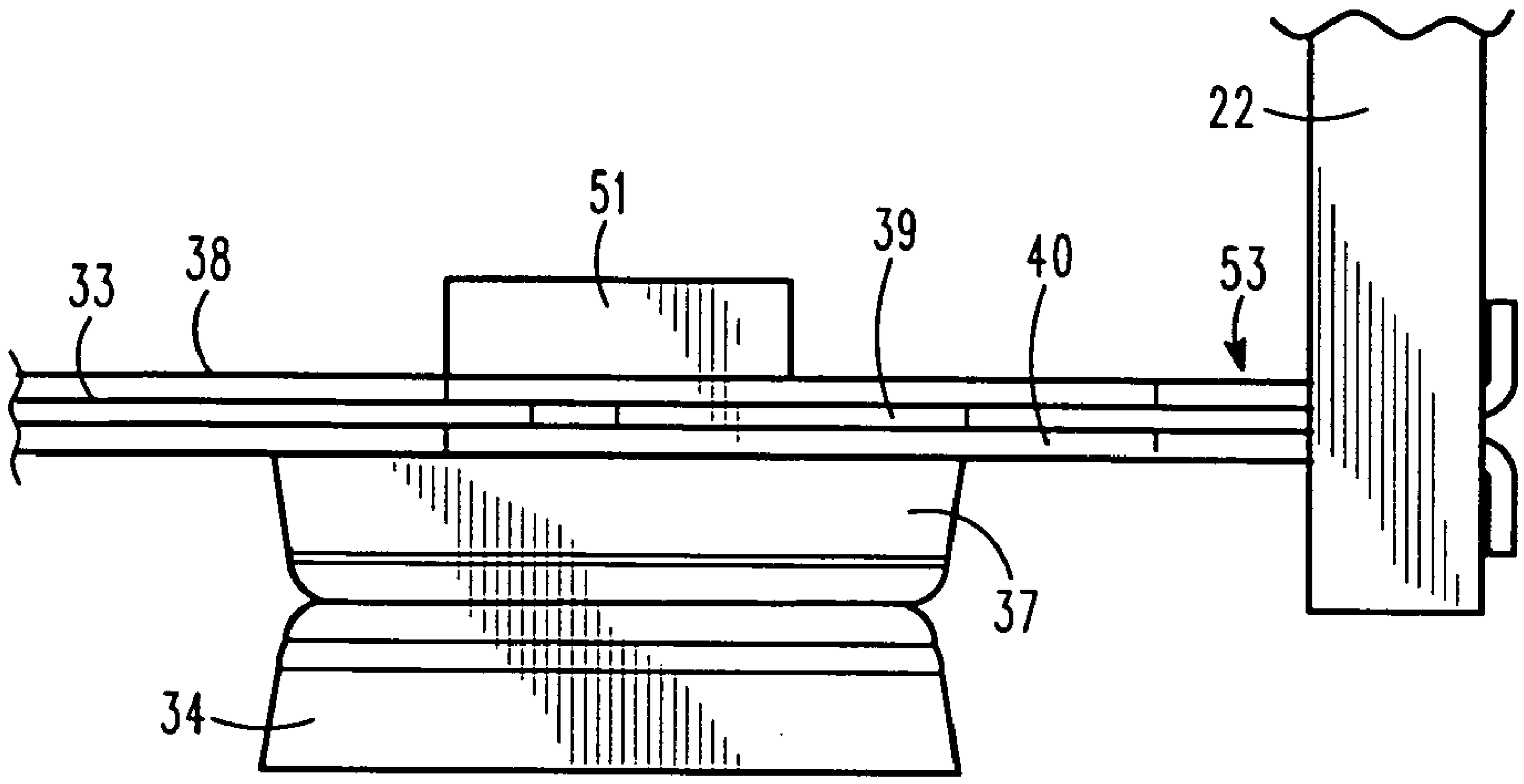


FIG. 12

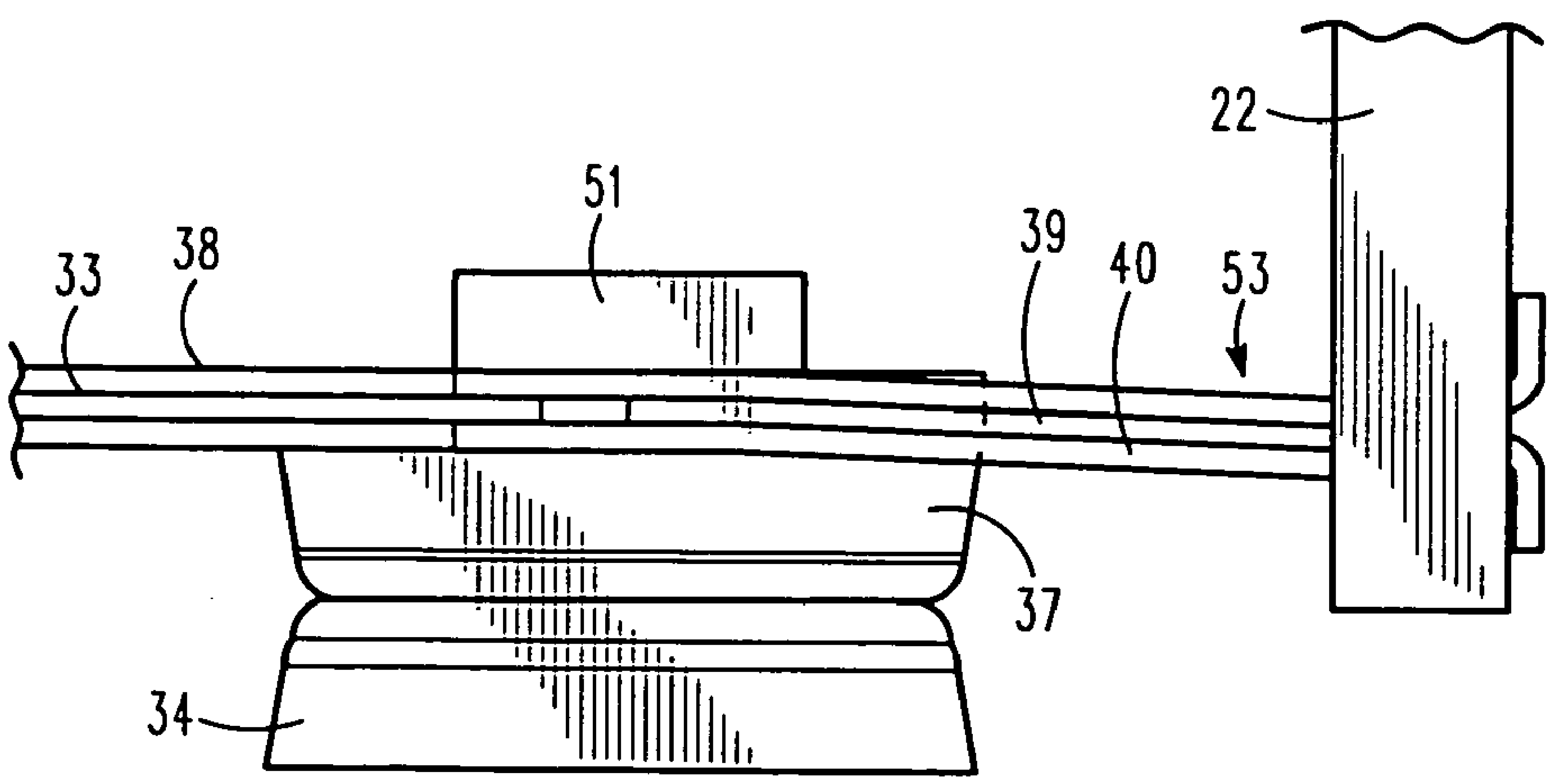


FIG. 13

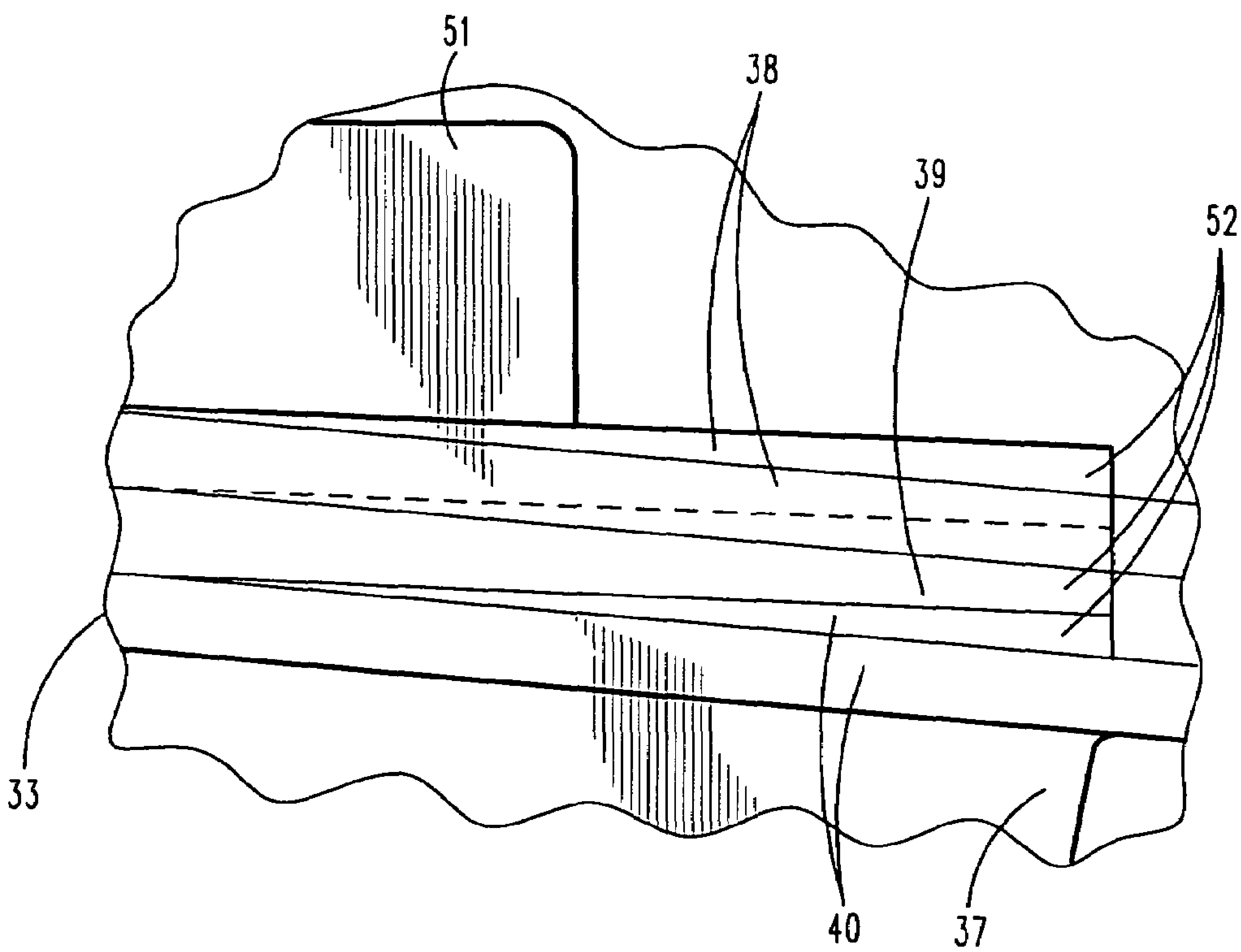


FIG. 14

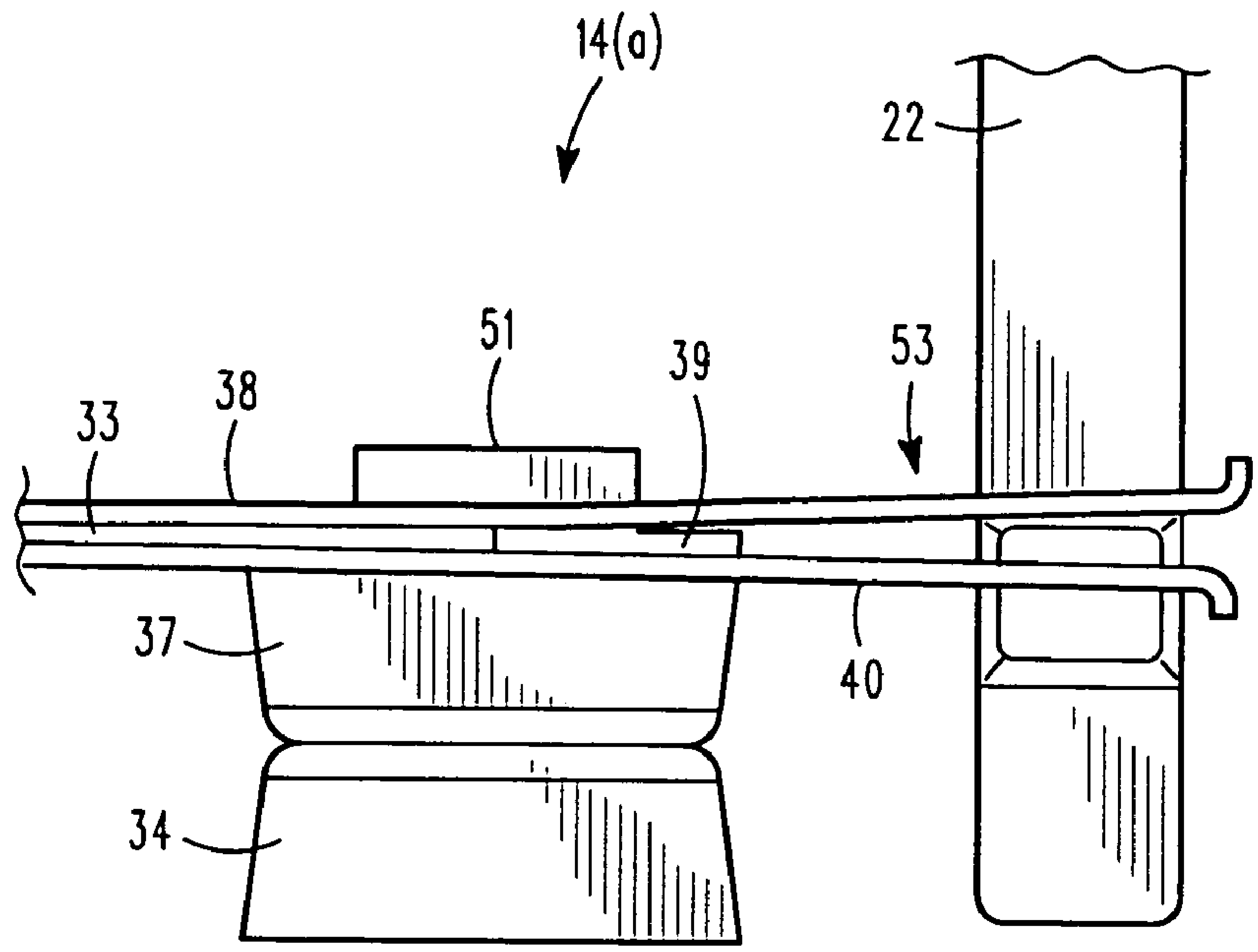
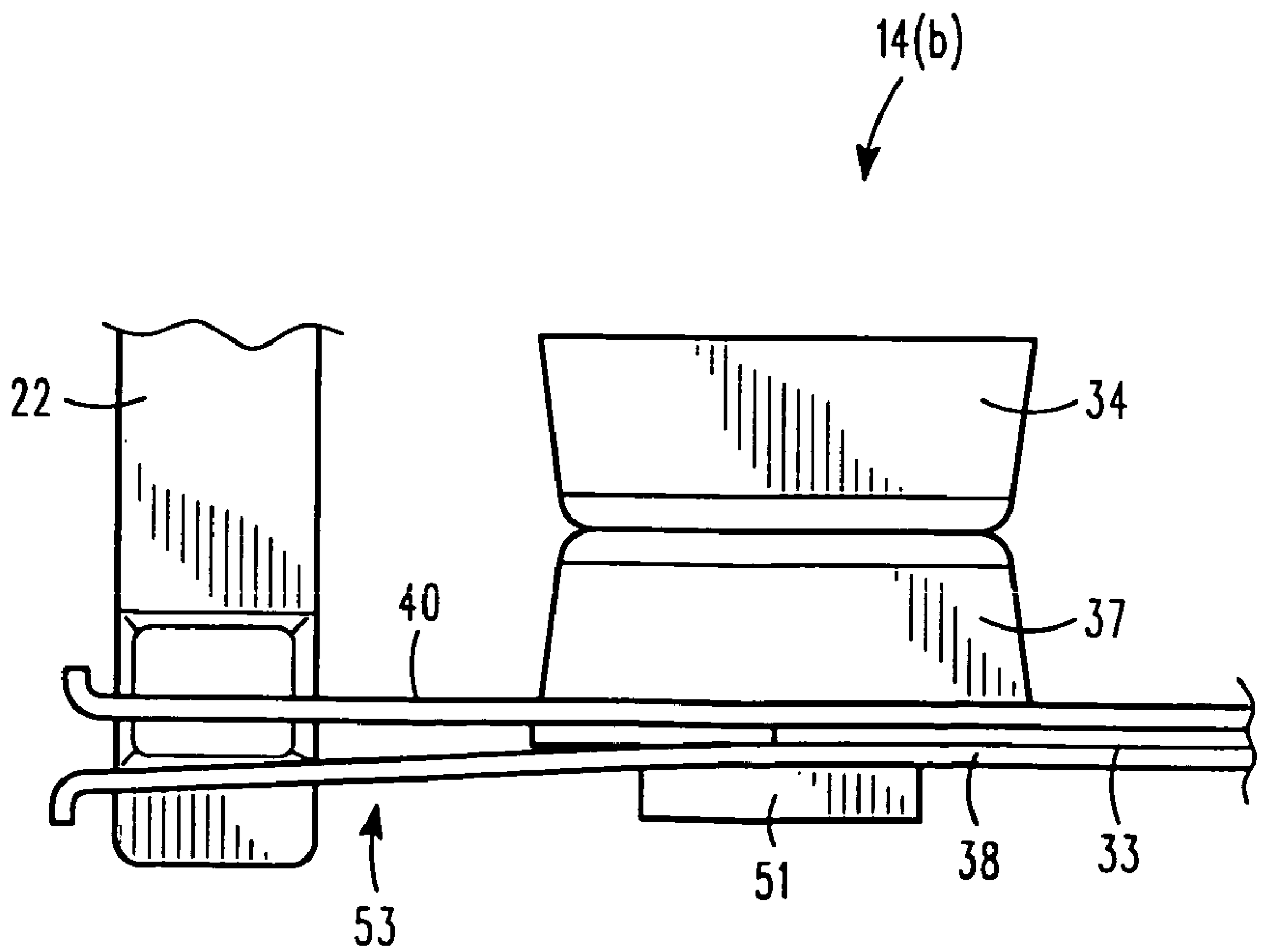


FIG. 15



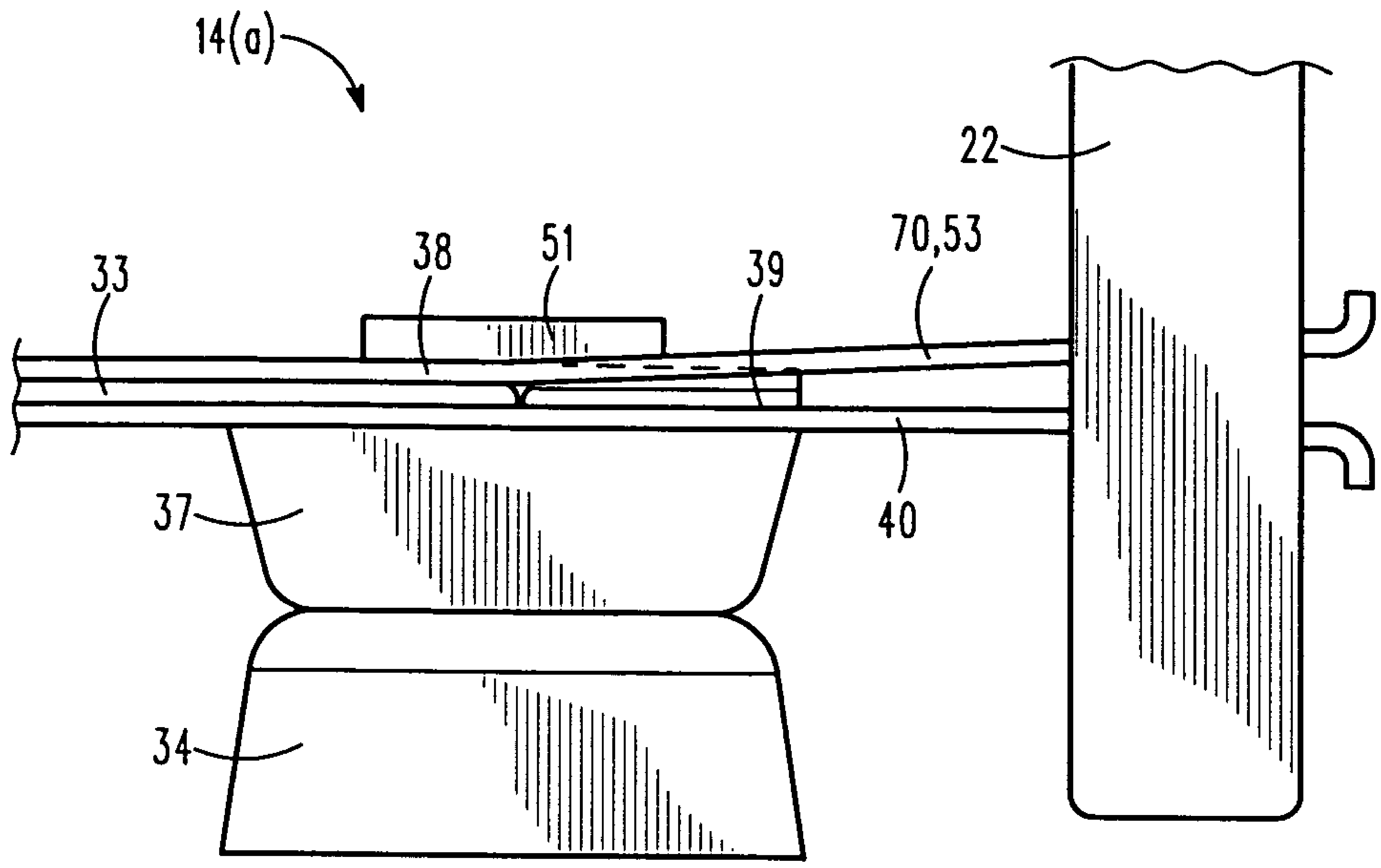


FIG. 16

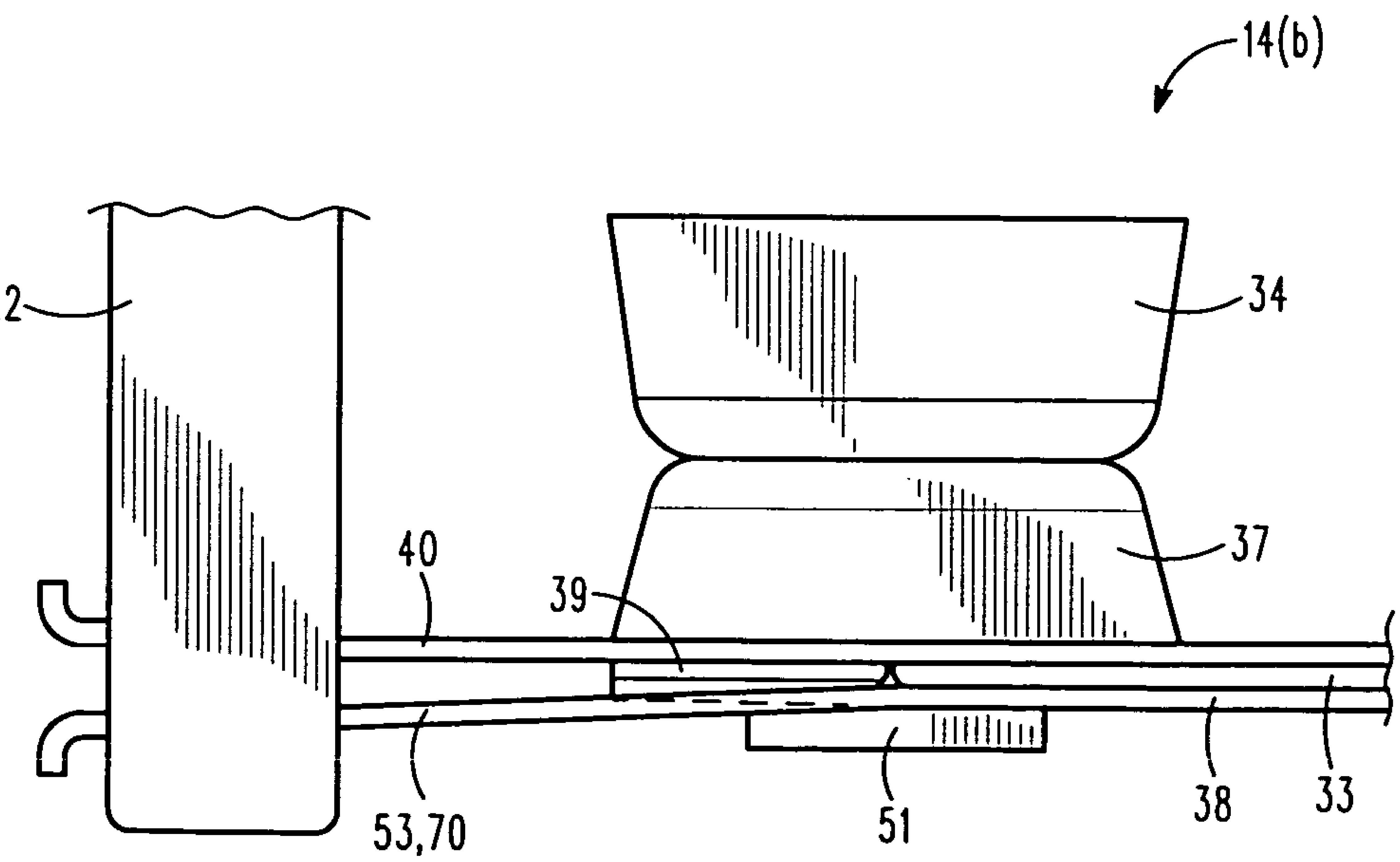


FIG. 17

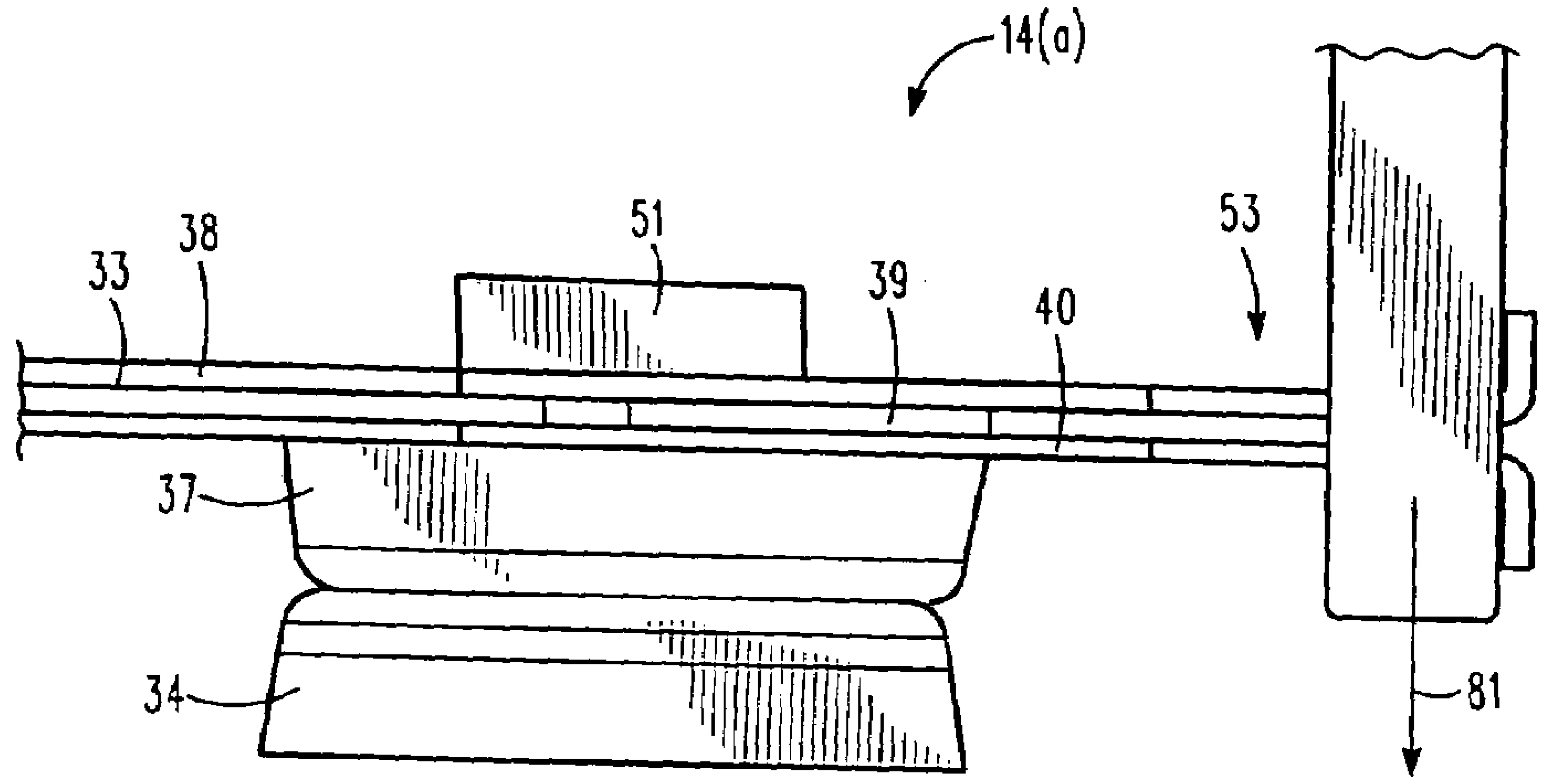


FIG. 18

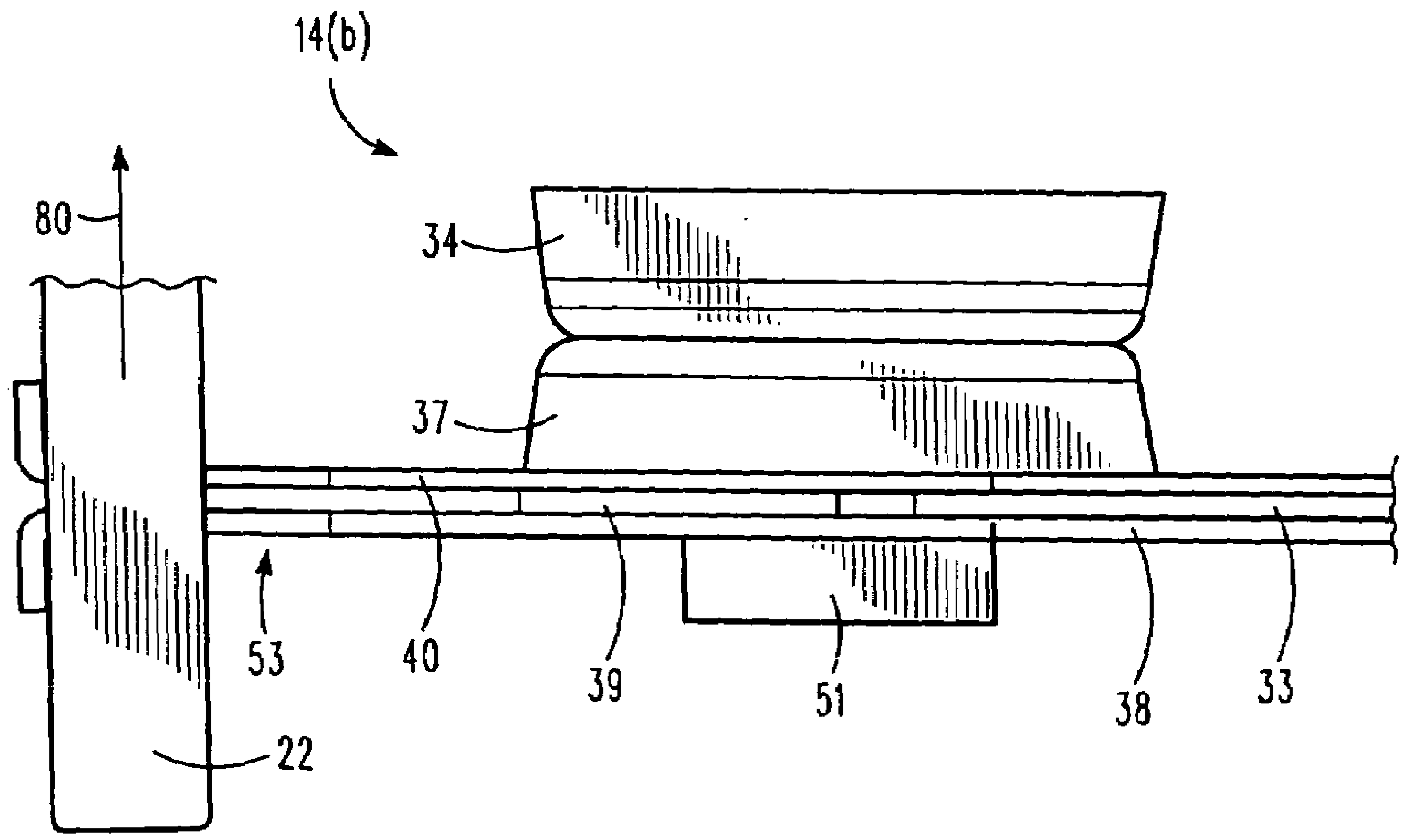


FIG. 19

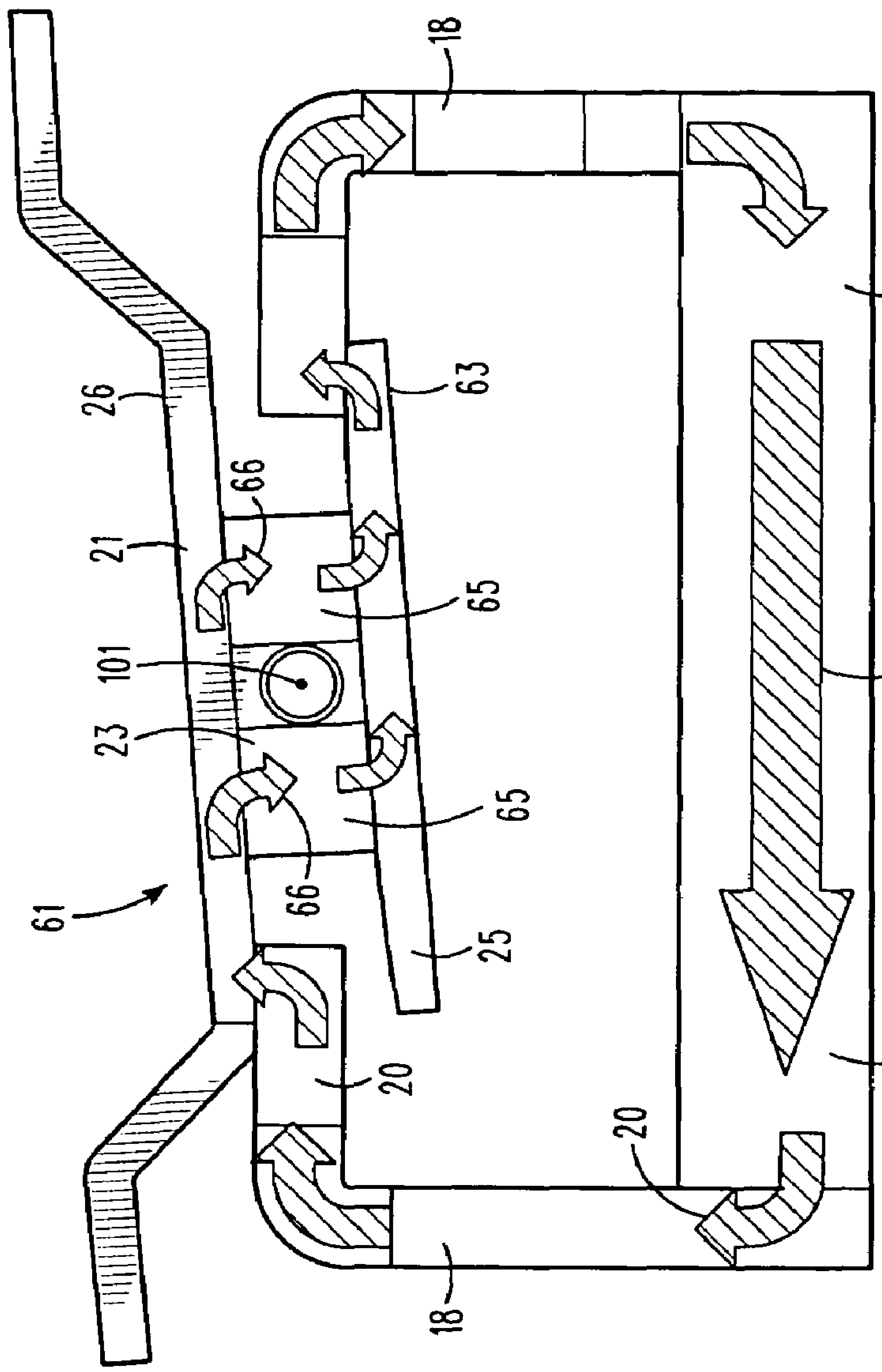


FIG. 20

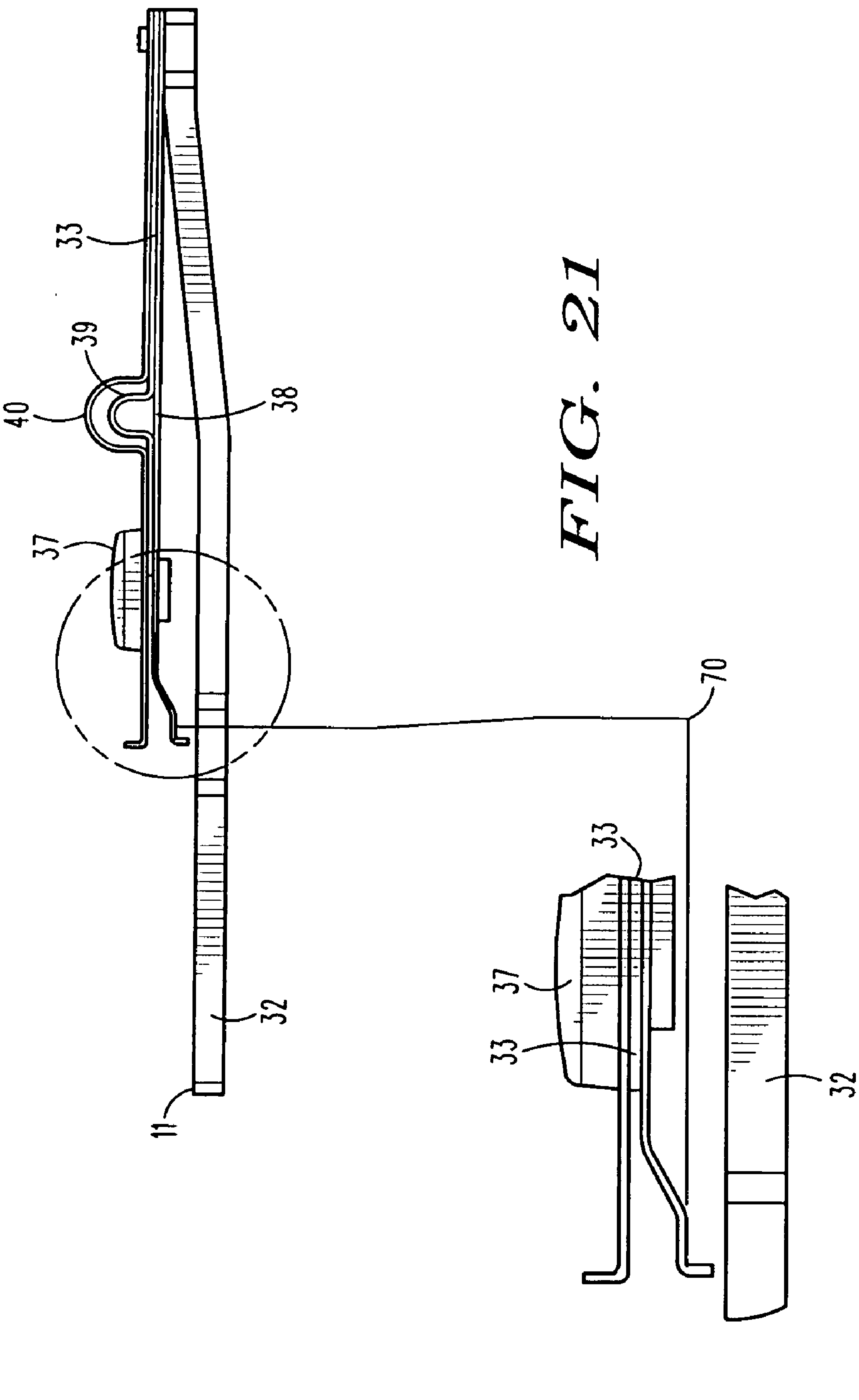


FIG. 21

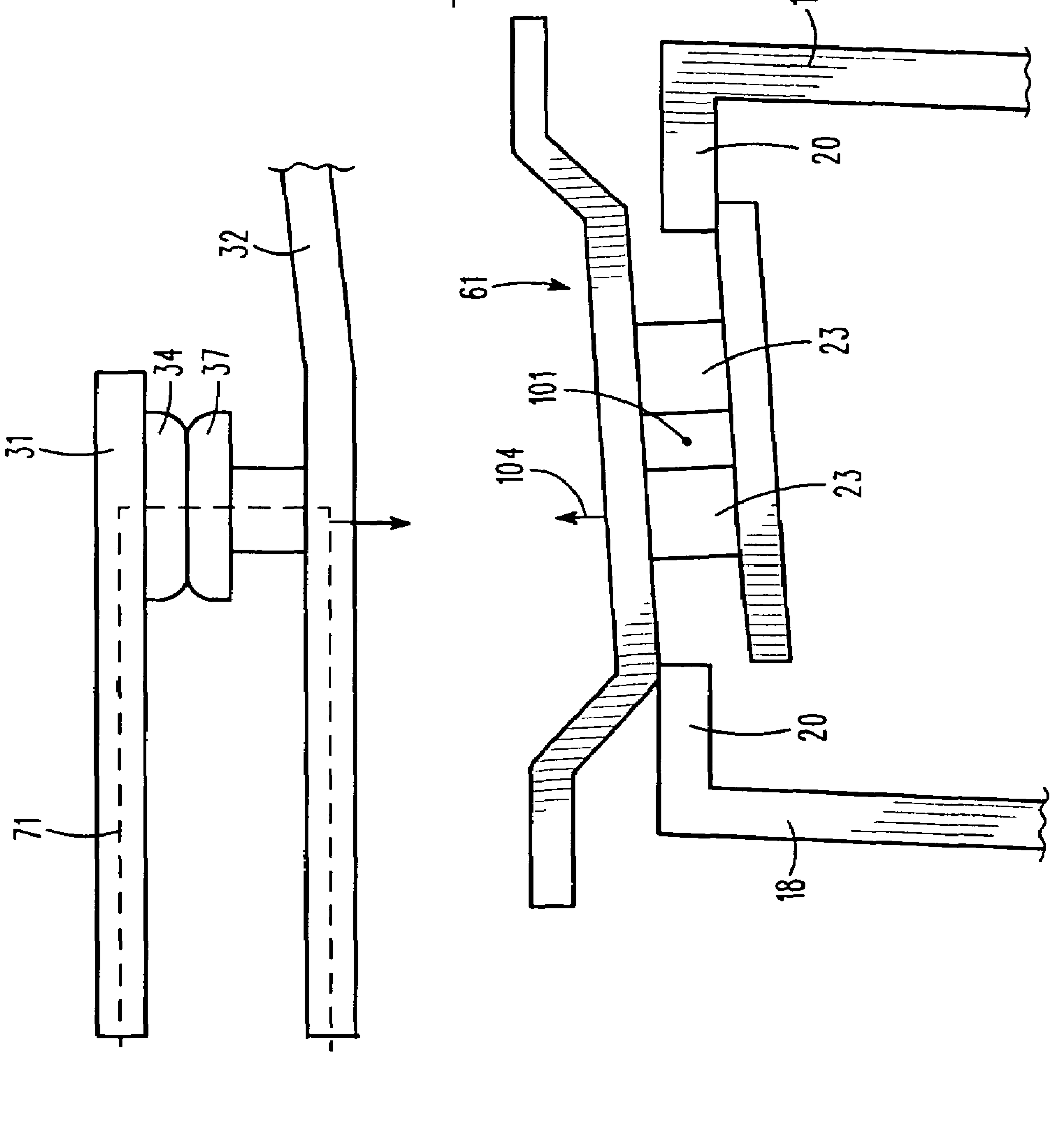


FIG. 22

ELECTROMAGNETIC RELAY ASSEMBLY

PRIOR HISTORY

This application is a continuation-in-part patent application claiming the benefit of pending U.S. patent application Ser. No. 11/888,519 filed in the United States Patent and Trademark Office on Aug. 1, 2007.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The disclosed invention generally relates to an electromagnetic relay assembly incorporating a uniquely configured armature assembly. More particularly, the disclosed invention relates to an electromagnetic relay assembly having a magnetically actuable rotor assembly for linearly displacing opposing switch actuators for selectively closing two switch mechanisms.

2. Brief Description of the Prior Art

Generally, the function of an electromagnetic relay is to use a small amount of power in the electromagnet to move an armature that is able to switch a much larger amount of power. By way of example, the relay designer may want the electromagnet to energize using 5 volts and 50 milliamps (250 milliwatts), while the armature can support 120 volts at 2 amps (240 watts). Relays are quite common in home appliances where there is an electronic control turning on (or off) some application device such as a motor or a light. The present teachings are primarily intended for use as a two pole, 200-amp passing electromagnetic relay assembly. It is contemplated, however, that the essence of the invention may be applied in other similarly constructed relay assemblies, having unique construction and functionality as enabled by the teachings of the two pole embodiment set forth in this disclosure. Several other electromagnetic relay assemblies reflective of the state of the art and disclosed in United States patents are briefly described hereinafter.

U.S. Pat. No. 6,046,660 ('660 patent), which issued to Gruner, discloses a Latching magnetic relay assembly with a linear motor. The '660 patent teaches a latching magnetic relay capable of transferring currents of greater than 100 amps for use in regulating the transfer of electricity or in other applications requiring the switching of currents of greater than 100 amps. A relay motor assembly has an elongated coil bobbin with an axially extending cavity therein. An excitation coil is wound around the bobbin. A generally U shaped ferromagnetic frame has a core section disposed in and extending through the axially extending cavity in the elongated coil bobbin. Two contact sections extend generally perpendicularly to the core section and rises above the motor assembly. An actuator assembly is magnetically coupled to the relay motor assembly. The actuator assembly is comprised of an actuator frame operatively coupled to a first and a second generally U-shaped ferromagnetic pole pieces, and a permanent magnet. A contact bridge made of a sheet of conductive material copper is operatively coupled to the actuator assembly.

U.S. Pat. No. 6,246,306 ('306 patent), which issued to Gruner, discloses an Electromagnetic Relay with Pressure Spring. The '306 patent teaches an electromagnetic relay having a motor assembly with a bobbin secured to a housing. A core is adjacently connected below the bobbin except for a core end, which extends from the bobbin. An armature end magnetically engages the core end when the coil is energized. An actuator engages the armature and a plurality of center contact spring assemblies. The center contact spring assembly is comprised of a center contact spring which is not pre bent and is ultrasonically welded onto a center contact terminal. A normally open spring is positioned relatively parallel to a center contact spring. The normally open spring is ultrasonically welded onto a normally open terminal to form a normally open outer contact spring assembly. A normally closed outer contact spring is vertically positioned with respect to the center contact spring so that the normally closed outer contact spring assembly is in contact with the center contact spring assembly, when the center contact spring is not being acted upon by the actuator. The normally closed spring is ultrasonically welded onto a normally closed terminal to form a normally closed assembly. A pressure spring pressures the center contact spring above the actuator when the actuator is not in use.

U.S. Pat. No. 6,252,478 ('478 patent), which issued to Gruner, discloses an Electromagnetic Relay. The '478 patent teaches an electromagnetic relay having a motor assembly with a bobbin secured to a frame. A core is disposed within the bobbin except for a core end which extends from the bobbin. An armature end magnetically engages the core end when the coil is energized. An actuator engages the armature and a plurality of movable blade assemblies. The movable blade assembly is comprised of a movable blade ultrasonically welded onto a center contact terminal. A normally open blade is positioned relatively parallel to a movable blade. The normally open blade is ultrasonically welded onto a normally open terminal to form a normally open contact assembly. A normally closed contact assembly comprised of a third contact rivet and a normally closed terminal. A normally closed contact assembly is vertically positioned with respect to the movable blade so that the normally closed contact assembly is in contact with the movable blade assembly when the movable blade is not being acted upon by the actuator.

U.S. Pat. No. 6,320,485 ('485 patent), which issued to Gruner, discloses an Electromagnetic Relay Assembly with a Linear Motor. The '485 patent teaches an electromagnetic relay capable of transferring currents of greater than 100 amps for use in regulating the transfer of electricity or in other applications requiring the switching of currents of greater than 100 amps. A relay motor assembly has an elongated coil bobbin with an axially extending cavity therein. An excitation coil is wound around the bobbin. A generally U shaped ferromagnetic frame has a core section disposed in and extending through the axially extending cavity in the elongated coil bobbin. Two contact sections extend generally perpendicularly to the core section and rises above the motor assembly. An actuator assembly is magnetically coupled to the relay motor assembly. The actuator assembly is comprised of an actuator frame operatively coupled to a first and a second generally U-shaped ferromagnetic pole pieces, and a permanent magnet. A contact bridge made of a sheet of conductive material copper is operatively coupled to the actuator assembly.

U.S. Pat. No. 6,563,409 ('409 patent), which issued to Gruner, discloses a Latching Magnetic Relay Assembly. The '409 patent teaches a latching magnetic relay assembly comprising a relay motor with a first coil bobbin having a first excitation coil wound therearound and a second coil bobbin having a second excitation coil wound therearound, both said first excitation coil and said second excitation coil being identical, said first excitation coil being electrically insulated from said second excitation coil; an actuator assembly magnetically coupled to both said relay motor, said actuator assembly having a first end and a second end; and one or two groups of contact bridge assemblies, each of said group of contact bridge assemblies comprising a contact bridge and a spring.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an electromagnetic relay assembly having certain means for damping contact vibration intermediate contacts of the switching assemblies. It is a further object of the present invention to provide an armature assembly having an axis of rotation and which rotates under the influence of the magnetic field created or imparted from an electromagnetic coil assembly. The armature assembly linearly displaces a two switch actuators for opening and closing the switch assemblies of the relay. To achieve these and other readily apparent objectives, the electromagnetic relay assembly of the present disclosure comprises an electromagnetic coil assembly, an armature bridge assembly, and first and second switch assemblies, as described in more detail hereinafter.

The coil assembly essentially comprises a coil, a C-shaped yoke assembly, and a coil axis. The coil is wound around the coil axis, and the yoke assembly comprises first and second yoke arms. Each yoke arm comprises an axial yoke portion that is coaxially alignable with the coil axis and together form the back of the C-shaped yoke assembly. Each yoke arm further comprises a yoke terminus, which yoke termini are coplanar and substantially parallel to the coil axis.

The armature bridge assembly is rotatable about an axis orthogonally spaced from the coil axis and coplanar with the yoke termini. The armature bridge assembly thus comprises a bridge axis of rotation, a bridge, and two actuator arms. The bridge comprises a medial field pathway relative closer in proximity to the coil axis, a lateral field pathway relatively further in proximity to the coil axis, and longitudinally or axially spaced medial-to-lateral or lateral-to-medial field pathways (or transverse field pathways) extending intermediate the medial and lateral pathways. The actuator arms are cooperable with the lateral field pathway via the first ends thereof and extend laterally away from the lateral field pathway.

The switch assemblies each essentially comprise switch terminals and a spring assembly between the switch terminals. The spring assemblies are is attached second ends of the actuator arms. The yoke termini are received intermediate the medial and lateral pathways. As is standard and well-established in the art, the coil receives current and creates or imparts a magnetic field, which magnetic field is directable through the bridge assembly via the yoke termini for imparting bridge rotation about the bridge axis of rotation and linearly displacing the actuator arms. The displaceable actuator arms function to actuate the spring assemblies intermediate an open contact position and a closed contact position, which closed contact positions enables current to pass through the switch assemblies via the switch termini.

Certain peripheral features of the essential electromagnetic relay assembly include certain means for enhancing spring over travel, which means function to increase contact pressure intermediate the switch terminals when the spring assemblies are in the closed position. The means for enhancing spring over travel further provide means for contact wiping or contact cleansing via the enhanced contact or increased contact pressure. In other words, the enhanced conduction path through the contact interface may well function to burn off residues and/or debris that may otherwise come to rest at the contact surfaces. The means for enhancing spring over travel may well further function to provide certain means for damping contact bounce or vibration intermediate the first and second contacts when switching from the open position to the closed position.

Other objects of the present invention, as well as particular features, elements, and advantages thereof, will be elucidated or become apparent from, the following description and the accompanying drawing figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Other features of our invention will become more evident from a consideration of the following brief description of patent drawings:

FIG. **1** is a first top plan view of the electromagnetic relay assembly of the present invention with cover removed and first and second switch assemblies in a closed position.

FIG. **2** is a second top plan view of the electromagnetic relay assembly of the present invention with cover removed and the first and second switch assemblies in a closed position.

FIG. **2**(*a*) is a fragmentary enlarged sectional view as sectioned from the assembly depicted in FIG. **2** showing the rotor assembly and rotor mount.

FIG. **3** is a diagrammatic plan type depiction of the rotor assembly, actuator arms, and switch assemblies in a closed position as separated from the relay housing and coil assembly for enhancing understanding of the structural relationship therebetween.

FIG. **4** is a diagrammatic plan type depiction of the rotor assembly, actuator arms, and switch assemblies in an open position as separated from the relay housing and coil assembly for enhancing understanding of the structural relationship therebetween.

FIG. **5** is an exploded top perspective view of a relay assembly according to the present invention.

FIG. **6** is an exploded perspective view of the coil assembly according to the present invention.

FIG. **7** is an exploded perspective view of the rotor assembly according to the present invention.

FIG. **8** is an exploded perspective view of a first type of first switch terminal assembly and triumvirate spring assembly with contact buttons according to the present invention.

FIG. **9** is an exploded perspective view of a second type of second switch terminal assembly with contact buttons according to the present invention.

FIG. **10** is an exploded perspective view of a second type of first switch terminal assembly and triumvirate spring assembly with contact buttons according to the present invention.

FIG. **11** is an exploded perspective view of a second type of second switch terminal assembly with contact buttons according to the present invention.

FIG. **12** is a fragmentary side view depiction of an alternative triumvirate spring assembly, the contact buttons, and an armature arm of the present invention showing the contact buttons in a closed position with the triumvirate spring assembly in a substantially linear configuration before over travel.

FIG. **13** is a fragmentary side view depiction of the triumvirate spring assembly, contact buttons, and armature arm otherwise depicted in FIG. **12** showing the contact buttons in a closed position with the triumvirate spring assembly in an over travel position for enhancing contact pressure intermediate the contact buttons.

FIG. **14** is an enlarged fragmentary side view depiction of the junction at the triumvirate spring assembly and the upper contact button otherwise shown in FIG. **13** depicting the triumvirate spring assembly in the over travel position for enhancing contact pressure intermediate the contact buttons.

FIG. **15** is a dual fragmentary side view depiction of opposed, preferred triumvirate spring assemblies, contact buttons, and armature arm assemblies of the present invention showing the contact buttons in a closed position showing the respective triumvirate spring assemblies such that two springs are in a substantially linear configuration and one spring is in an offset configuration before over travel.

FIG. **16** is an enlarged fragmentary side view depiction of the junction at the right most triumvirate spring assembly and the upper contact button otherwise shown in FIG. **15** depicting the spring with offset before over travel.

FIG. **17** is an enlarged fragmentary side view depiction of the junction at the left most triumvirate spring assembly and the upper contact button otherwise shown in FIG. **15** depicting the spring with offset before over travel.

FIG. **18** is an enlarged fragmentary side view depiction of the junction of the triumvirate spring assembly and the upper contact button otherwise shown in FIG. **16** depicting the spring with offset after over travel.

FIG. **19** is an enlarged fragmentary side view depiction of the junction of the triumvirate spring assembly and the upper contact button otherwise shown in FIG. **17** depicting the spring with offset after over travel.

FIG. **20** is a diagrammatic depiction of the flux flow through the C-shaped core assembly and the rotor assembly of the electromagnetic relay assembly depicting a diverted and divided field flow through the rotor assembly.

FIG. **21** is a dual side view depiction of a switch terminal assembly showing (1) the assembly as operatively connected to a triumvirate spring assembly and a contact button, the triumvirate spring assembly showing first and second springs with centrally located C-shaped folds, and a third spring with an end-located bend, and (2) an enlarged fragmentary sectional view depicting the end-located bend of the third spring in greater detail.

FIG. **22** is a diagrammatic depiction of a threshold current path directed through the relay terminals as disposed in adjacency to the rotatable armature assembly and depicting a terminal-sourced magnetic field greater in magnitude than an armature-sourced magnetic field for rotating the armature assembly toward a circuit-opening position.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings with more specificity, the preferred embodiment of the present invention concerns an two-pole electromagnetic relay assembly **10** as generally illustrated and referenced in FIGS. **1**, **2**, and **5**. The electromagnetic relay assembly **10** of the present invention essentially functions to selectively enable current to pass through two sets of switch termini **11**. The switch termini **11** are illustrated and referenced in FIGS. **1**, **2**, **3-5**, and **8-11**. To achieve these and other readily apparent functions, the two-pole electromagnetic relay assembly **10** of the present invention preferably comprises an electromagnetic coil assembly **12** as generally illustrated and referenced in FIGS. **1**, **2**, **5**, and; a rotatable armature assembly **13** as generally illustrated and referenced in FIGS. **1-5**; and first and second switch assemblies **14** as generally illustrated and referenced in FIGS. **1**, **2**, **3**, and **4**.

The coil assembly **12** of the relay **10** preferably comprises a current-conductive coil **15** as illustrated and referenced in FIGS. **1**, **2**, and **6**; a C-shaped core or yoke assembly **16** as illustrated in exploded form in FIG. **6** and illustrated in diagrammatic form in FIG. **15**; and a longitudinal coil axis. It may be seen or understood from an inspection of the noted figures that the current-conductive coil **15** is wound around the coil axis and comprises certain electromagnet-driving termini **17** as illustrated and referenced in FIG. **6**. The yoke assembly or C-shaped core assembly **16** of the present invention is axially received within the coil **15** and preferably comprises first and second yoke arms **18** as illustrated and referenced in FIGS. **5** and **6** and as diagrammatically depicted in FIGS. **15** and **17**. It may be seen from an inspection of FIG. **6** that the yoke arms **18** each comprise an axial yoke portion **19** and a substantially planar yoke terminus **20**, which yoke termini **20** are preferably parallel to the coil axis when in an assembled state.

The rotatable armature assembly **13** of the present invention may be described as preferably comprising a rotor assembly **21** as generally illustrated and referenced in FIGS. **1-5**, **7**, **15**, and **17**; first and second actuators or actuator arms **22** as generally illustrated and referenced in FIGS. **1**, **2**, **3-5**, and **13**; and an armature axis of rotation **101** as depicted and referenced at a point in FIGS. **2**(*a*)-**4**, **15**, and **17**, and as a broken line in FIG. **7**. The rotor assembly **21** preferably comprises first and second uniformly directed or polarized rotor magnets **23** as illustrated and referenced in FIGS. **7** and **15**; a rotor plate **25** as illustrated and referenced in FIGS. **3-5**, **7**, and **15**; a rotor bracket **26** as illustrated and referenced in FIGS. **3-5**, **7**, and **15**; a rotor housing **27** as illustrated in exploded form in FIG. **7**; a rotor pin **29** as illustrated and referenced in FIG. **5**; and a rotor mount **30** as illustrated and referenced in FIGS. **1**, **2**(*a*), and **5**.

It may be seen from an inspection of the noted figures that the rotor bracket **26** is attached or otherwise cooperatively associated with first ends of the actuator arms **22**, and that the rotor plate **25** and the rotor bracket **26** (or portions thereof) are preferably oriented parallel to one another by way of the rotor housing **27**. It will be seen that the terminal ends of rotor bracket **26** are zigzagged or zigzag extend from the central portion of the rotor bracket **26**, which central portion is parallel to the rotor plate **25**. The terminal ends of the rotor bracket **26**, as zigzag extended from, and integrally formed with the rotor bracket **26**, attach the rotor bracket **26** to the actuator arms **22**.

It may be further seen that the first and second rotor magnets **23** are equally dimensioned and extend intermediate the rotor plate **25** and the central portion of the rotor bracket **26** for simultaneously and equally spacing the rotor plate **25** and the central portion of the rotor bracket **26** and for further providing a guide way or pathway for so-called Lorenz current or magnetic flux to be effectively transversely directed across the rotor or bridge assembly **21** as diagrammatically depicted in FIG. **15**.

In this last regard, it is contemplated that the armature assembly **13** may be thought of as an armature bridge assembly, which bridge assembly comprises a bridge axis of rotation (akin to the armature axis of rotation **101**) and a bridge in cooperative association with the armature arms **22**. In this context, the bridge may be thought of or described as preferably comprising a medial pathway (akin to the rotor plate **25**), a lateral pathway (akin to the rotor bracket **26**), and longitudinally or axially spaced medial-to-lateral or transverse pathways (akin to the first and second rotor magnets **23**. The armature arms **22** may thus be described as extending laterally away from the lateral pathway or rotor bracket **26** for engaging the switch assemblies **14**.

The rotor housing **27** essentially functions to receive, house, and position the first and second rotor magnets **23**, the rotor plate **25** and the rotor bracket **26** to form the bridge like structure of the armature assembly **13**. The rotor magnets **23** are uniformly directed such that like poles face the same rotor structure. For example, it is contemplated that the north poles of rotor magnets **23** may face the rotor bracket **26** (the south poles thereby facing the rotor plate **25**) or that the south poles of rotor magnets **23** may face the rotor bracket **26** (the north poles thereby facing the rotor bracket).

The rotor housing **27** may well further comprise a pin-receiving aperture or bore receiving the rotor pin **29**. The pin-receiving bore of the rotor housing **27** enables rotation of the bridge or armature assembly **13** about the armature axis of rotation **101**. The rotor pin **29**, extending through the pin-receiving bore, may be axially anchored at a lower end thereof by way of a relay housing **48** as illustrated and referenced in FIGS. **1-3**, and which relay housing **48** is sized and shaped to receive, house, and position the coil assembly **12**, the armature assembly **13**, and the switch assemblies **14**. It may be further readily understood from an inspection of FIG. **5** that the relay housing **48** may, but not necessarily, comprise or be cooperable with a relay cover **49**.

In this last regard, it will be recalled that the armature assembly **13** of present invention may be anchored or mounted by way of the rotor mount **30**. Rotor mount **30** may be cooperatively associated with the relay housing **48** (i.e. anchored to the relay housing **48**) for axially fixing the rotor pin **29**, the fixed rotor mount **30** receiving and anchoring an upper end of the rotor pin **29** so as to enable users of the relay to effectively operate the electromagnetic relay assembly **10** without the relay cover **49**. The rotor or bridge mount **30** or means for mounting the rotor assembly or bridge assembly may thus be described as providing certain means for enabling open face operation of the electromagnetic relay assembly **10**. It is contemplated, for example, that in certain scenarios a coverless relay assembly provides a certain benefit. For example, the subject relay assembly may be more readily observed during testing procedures. In any event, it is contemplated that the rotor mount **30** of the present invention enables cover-free operation of the electromagnetic relay assembly **10** by otherwise fixing the armature assembly **13** to the relay housing **48**.

The switch assemblies **14** of the present relay assembly **10** each preferably comprise a first switch terminal assembly **31** as generally illustrated and referenced in FIGS. **1**, **2**, **3-5**, **9**, **11**, and **17**; a second switch terminal assembly **32** as illustrated and referenced in FIGS. **1**, **2**, **3-5**, **8**, **10**, **16**, and **17**; and a triumvirate spring assembly **33** as illustrated and referenced in FIGS. **1**, **2**, **3-5**, **8**, **10**, **12**, **14**, and **16**. From an inspection of the noted figures, it may be seen that each first switch terminal assembly **31** preferably comprises a first set of contact buttons **34** and a first switch terminus as at **11**. Further, the second switch terminal assemblies **32** each preferably comprise a second switch terminus as at **11**.

The triumvirate spring assemblies **33** each preferably comprises a second set of contact buttons **37**; and a first spring **38**, a second spring **39**, and a third spring **40** as further illustrated and referenced in FIGS. **8**, **10**, **12-14**, and **16**. It may be further seen that the first springs **38** each preferably comprises a first set of contact-receiving apertures as at **41** and a first set of C-shaped apertures as at **42** in FIGS. **8** and **10**, as well as an end-located offset or bend as at **70** in FIGS. **16**, **17**, and **21**. The offset or bend **70** is relatively more abbreviated in FIG. **21** for clarity of inspection. Notably, the first C-shaped aperture **42** is preferably concentric about the first contact-receiving aperture **41**. The second springs **39** each preferably comprise a second set of contact-receiving apertures as at **43** and a first C-shaped fold or bend as at **44** in FIGS. **8** and **10**. It may be seen from an inspection of FIGS. **8** and **10** that the first C-shaped fold or bend **44** has a certain first radius of curvature. The third springs **40** each preferably comprises a third set of contact-receiving apertures as at **45**, and a second C-shaped fold as at **47**.

It may be further seen that the second C-shaped fold **47** has a certain second radius of curvature, which second radius of curvature is greater in greater in magnitude than the first radius of curvature (of the first C-shaped fold **44**). The second springs **39** are sandwiched intermediate the first and third springs **38** and **40** via the second contact buttons **37** as received or extended through the contact-receiving apertures **41**, **43**, and **45**. The first C-shaped folds **44** are concentric (about a fold axis) within the second C-shaped folds **47**. The first and second contact buttons **34** and **37** or contacts are spatially oriented or juxtaposed adjacent one another as generally depicted in FIGS. **1**, **2**, **3**, **4**, **12-14**, and **17**. In the preferred embodiment, the triumvirate spring assemblies **33** are biased in an open contact position intermediate the first and second switch termini **11** and attached to (the lateral end of) the armature arms **22**.

It is contemplated that the first and second C-shaped apertures **42**, and the end-located offset or bends **70** may well function to provide certain means for enhanced over travel for increasing contact pressure intermediate the contact buttons **34** and **37**. Notably, the third springs **40** do not have a C-shaped aperture or cut out, in contradistinction to the preferred embodiments set forth in U.S. patent application Ser. No. 11/888,519, filed in the United States Patent and Trademark Office on Aug. 1, 2007, from which this specification claims priority and which specification is hereby incorporated by reference thereto insofar as the subject matter here presented is supported by common matter therebetween. In the two-pole relay **10** of the present invention, the third spring **40** needs only flex more in a single direction due to the balanced, opposing spring assembly **14** set-up. In other words, the cut outs or apertures **42** on springs **38** allow for more over travel in opposing directions, which is not necessarily required in the opposite direction.

In this last regard, the reader is directed to FIGS. **12-14** and FIGS. **15-19**, respectively. From a consideration of FIGS. **12-14**, it may be seen that the terminal side ends **53** of the spring assembly **33** may be actuated past the planar portions of the spring assembly **33** immediately adjacent the stem **51** of contact button **37**. The planar portions of the spring assembly **33** immediately (and radially) adjacent the stem **51** of contact button **37** thus form button-stackable spring portions as at **52** in FIG. **14**. It may be seen that the button-stackable portions **52** stack upon the contact button **37** and that terminal side ends **53** of the elastically deform as at **50** for enabling said over travel. From a comparative consideration of FIGS. **15-19** (and referencing the push-closed switch assembly **14**(*a*) versus the pull-closed switch assembly **14**(*b*)), it may be seen that terminal side ends **53** of the springs **38** (comprising the offset or bends **70**) of the spring assemblies **33** may be actuated into a substantially planar configuration immediately adjacent the stem **51** of contact buttons **37**.

The material (preferably copper) of the spring elements having the C-shaped apertures is more readily and elastically deformable at the termini of the C-shaped apertures as at **50**. Notably, the elastic deformation of the material adjacent termini **50** does not result in appreciable embrittlement of the underlying material lattice (i.e. does not appreciably impart undesirable lattice dislocations) and thus the C-shaped aperture structure or feature of the triumvirate spring assembly provides a robust means for enhanced over travel for further providing certain added pressure intermediate the contact buttons **34** and **37** for improving conductive contact(s) therebetween. The end-located offset or bends **70**, located on springs **38**, provide further means for enhanced over travel for increasing contact pressure and reducing contact bounce of the contacts **34** and **37**.

Conduction through the contact buttons **34** and **37** is thus improved by way of the C-shaped aperture-enabled and/or enhanced over travel. It is contemplated that the enhanced contact and resulting conduction provides certain means for improved contact wiping, said means for contact wiping or contact cleansing thus being further enabled by way of the enhanced over travel. In this regard, it is contemplated that the relay assembly **10** of the present invention inherently has a self-cleansing feature as enabled by the C-shaped apertures **42**. Further, it is contemplated that the C-shaped apertures **42** (and offset or bend **70**) may well provide certain means for reducing contact bounce or for otherwise damping contact vibration intermediate the contact buttons **34** and **37** when switching from an open contact state or open switch position (as generally depicted in FIG. **4**) to a closed contact state or closed switch position (as generally depicted in FIGS. **1**, **2**, and **3**).

From an inspection of FIG. **15**, it may be readily understood that the core or yoke termini **20** are loosely received intermediate the rotor plate **25** and the rotor bracket **26**, and that the armature axis of rotation **101** is coplanar with the yoke termini **20**, which axis of rotation **101** extends through the rotor pin **29** (not specifically depicted in FIG. **15**). As should be readily understood, the current-conductive coil **15** functions to receive current and thereby creates a magnetic field as further depicted and referenced at vectors **102** in FIG. **15**. As may be seen from an inspection of the noted figure, the magnetic field **102** is directed through the yoke termini **20** via the rotor assembly (essentially defined by the rotor bracket **26**, the rotor magnets **23**, and the rotor plate **25**) for imparting armature or bridge rotation about the armature axis of rotation **101** via a magnetically induced torque.

The rotor bracket **26** thus functions to linearly displace the actuator arms **22** such that the first actuator arm is pulled and the second actuator arm is pushed. The displaced actuator arms **22** function to actuate the triumvirate spring assemblies **33** from a preferred spring-biased open position (as generally depicted in FIG. **4**) to a spring-actuated closed position (as generally depicted in FIG. **2**). The material construction of the relay assembly **10** (believed to be within the purview of those skilled in the art) and the closed position essentially function to enable 120-amp current to pass through the switch assemblies **14** via the contact buttons **34** and **37** and the switch termini **11**.

When the coil assembly **12** is currently dormant and the magnetic field is effectively removed, it is contemplated that a return spring may well function to enhance return of the triumvirate spring assembly **33** to the preferred spring-biased open position. Should a fault current condition arise, it is contemplated that the electromagnetic relay **10** may preferably further comprise certain closed contact default means, the closed contact default means for forcing the contact buttons **34** and **37** closed during said fault current or short circuit condition(s). In this regard, it is contemplated that the path followed by the Lorenz current or magnetic field path as generally depicted in FIG. **15** by vector arrows **102**.

It is further contemplated that the electromagnetic relay according to the present invention may comprise certain means for defaulting to an open contact position during threshold terminal-based current conditions. In this regard, it is noted from classical electromagnetic theory that streaming charge carriers develop a magnetic field in radial adjacency to the direction of the carrier stream. The reader is thus directed to FIG. **17** which is a diagrammatic depiction of a threshold current path as at **71** being directed through the relay terminals **31** and **32** via the contact buttons **34** and **37**. A magnetic force vector as at **103** is depicted as terminal-sourced via the charge carrier current flowing through the path **71**. After reaching certain threshold amperage, the magnetic field generated through the terminals **31** and **32** will interact with the permanent magnets or rotor magnets **23** of the rotatable armature assembly **13**. The magnets **23** have an inherent magnetic field directed outward as referenced at vector arrow **104**, the force of which is lesser in magnitude than the force at vector arrow **103**. The difference in force between **104** and **103** as directed causes the rotatable armature assembly **13** to rotate toward an open contact position as further diagrammatically shown in FIG. **17**. This feature can be calibrated by the size and strength of the magnets **23** and the distance between the armature and stationary contacts.

While the above descriptions contain much specificity, this specificity should not be construed as limitations on the scope of the invention, but rather as an exemplification of the invention. For example, the invention may be said to essentially teach or disclose an two-pole electromagnetic relay assembly for enabling current to pass through switch termini, which electromagnetic relay assembly comprising a coil assembly, a bridge assembly, and two switch assemblies. The coil assembly comprises a coil, a coil axis, and a C-shaped core. The coil is wound around its coil axis, and the coil axis extends through the core **60** in FIG. **15**. The core **60** comprises core termini **20**, which core termini **20** are substantially parallel to the coil axis.

The bridge assembly comprises an axis of rotation as at **101** and a bridge as at **61** in FIG. **15**; and switch actuators as at **22**. The bridge **61** comprises a medial field pathway **63** (i.e. a pathway relatively closer in proximity to the core **60**), a lateral field pathway **64** (i.e. a pathway relatively further in proximity to the core **60**), and axially spaced transverse pathways **65** for guiding the field as at **102** intermediate the medial and lateral field pathways **63** and **64**. The actuator arms **22** are cooperable with, and extend away from, the lateral pathway **64** (not specifically depicted in FIG. **15**). The core termini **20** are preferably coplanar with the axis of rotation **101** and received intermediate the medial and lateral pathways **63** and **64**.

It is contemplated that the transverse pathways **65** provide certain field-diversion means for transversely diverting the magnetic field **102** relative to the coil axis and magnetically inducing a torque, which magnetically induced torque functions to actuate (push-pull) the switch actuators **22**. Said field diversion means may be further described as comprising certain field division means (there being two axis-opposing paths as at **66** in FIG. **15**) for creating a magnetic couple about the magnetically induced torque.

The switch assemblies **14** are further cooperable with the actuator arms **22**, which actuator arms **22** are essentially a coupling intermediate the bridge assembly **61** and the switch assemblies **14**. The coil **15** functions to create or impart a magnetic field as vectorially depicted at **102**. The magnetic field **102** is directable through the bridge assembly **61** via the core termini **20** for imparting bridge rotation about the axis of rotation **101** via magnetically induced torque. The bridge rotation functions to displace the actuator arms **22**, which displaced actuator arms **22** physically open and close the switch assembly **14**. As is most readily understood in the arts, the closed switch assembly **14** enables current to pass therethrough.

The switch assemblies **14** comprise certain spring means for enhancing spring over travel, said means for enhancing the closed switch position by way of increasing the contact pressure intermediate contact buttons **34** and **37**. The spring means for enhancing spring over travel further provide contact wiping means, and vibration damping means. The contact wiping means are contemplated to effectively self-cleanse the switch assemblies **14**, and the vibration damping means function to damp contact vibration when switching from open to closed switch positions. The spring means for enhancing spring over travel may thus be said to enhance the closed switch position by increasing contact pressure intermediate the contacts, by maintaining a residue free contact interface, and by damping contact vibration when closing the contacts. The electromagnetic relay **10** thus enables current to pass through switch termini, and essentially a coil assembly, a rotatable bridge assembly, and first and second switch assemblies. The coil assembly operates to create a temporary coil-emanating magnetic field. The rotatable bridge assembly comprises opposing switch actuators and positions a permanent bridge-based magnetic field. The first and second switch assemblies are cooperable with the switch actuators such that when the coil-emanating magnetic field is directed through the bridge assembly, the same imparts bridge rotation (as at **82** in FIG. **3**) via the bridge-based magnetic field. The bridge rotation displaces the switch actuators for opening and closing the switch assemblies. A first switch actuator pull-closes a first switch assembly as depicted at vector arrow **80** in FIGS. **3** and **19**, and a second switch actuator push-closes a second switch assembly as depicted at vector arrow **81** in FIGS. **3** and **18**.

The relay **10** thus provides a fully balanced motor assembly because the two contact systems are essentially situated in opposing directions to one another. This means the spring forces of one contact system are pointing toward the coil, and the other contact system has the forces pointing away from the coil. Since these contact systems are identical, the forces are automatically balanced. It should be further recalled that the relay is operational without the cover. A rotor mount on top of the coil assembly operates to fix the rotor into place. This allows the relay to be tested and operated without its cover on. The Lorentz current path withstands fault current conditions. The current path has been reversed within the relay so that the magnetic forces incurred during a fault or short circuit condition will force the contacts closed instead of open. Certain of the C-shaped cut outs around the contact buttons allow the armatures to have more over travel, which over travel has the following exemplary effects: increased contact pressure; increased contact wiping (i.e. since there is more contact pressure, the contacts will rub against one another wiping away any debris or burn residue); and reduced contact bounce when closing the contacts.

Although the invention has been described by reference to a number of embodiments it is not intended that the novel device or relay be limited thereby, but that modifications thereof are intended to be included as falling within the broad scope and spirit of the foregoing disclosure and the appended drawings. For example, the foregoing specifications support an electromagnetic relay assembly primarily intended for use as a double pole, 200-amp to 250-amp passing relay assembly. It is contemplated, however, that the essence of the invention may be applied in other similarly constructed relay assemblies, having unique utility in their own right, and which are enabled by the teachings of the two-pole embodiment set forth in this disclosure.

We claim:

1. An electromagnetic relay, the electromagnetic relay for enabling current to pass through switch termini, the electromagnetic relay comprising:

an electromagnetic coil assembly, the coil assembly comprising a coil, a C-shaped yoke assembly, and a coil axis, the coil being wound around the coil axis, the yoke assembly comprising first and second yoke arms, the yoke arms each comprising an axial yoke portion and a yoke terminus;

an armature bridge assembly, the armature bridge assembly comprising a bridge axis of rotation, a bridge, and opposing actuator arms, the bridge comprising a medial field pathway, a zigzagged lateral field pathway, and longitudinally spaced transverse field pathways, the actuator arms extending from terminal portions of the lateral field pathway; and

two switch assemblies, the switch assemblies each comprising switch terminals and a spring assembly, the spring assemblies being attached to the actuator arms and extending intermediate the switch terminals, the yoke termini being received intermediate the medial and lateral field pathways, the bridge axis of rotation being coplanar with the yoke termini, the actuator arms and zigzagged lateral field pathway extending non-radially relative to the bridge axis of rotation, the coil for receiving current and creating a magnetic field, the magnetic field being directable through the bridge assembly via the yoke termini for imparting bridge rotation about the bridge axis of rotation and displacing the actuator arms, the displaceable actuator arms for actuating the spring assemblies intermediate an open contact position and a closed contact position, the closed contact position for enabling current to pass through the switch assemblies via the switch termini.

2. The electromagnetic relay of claim **1** comprising spring-based aperture means for enhancing spring over travel, said means for increasing contact pressure intermediate the switch terminals when the spring assemblies are in the closed contact position.

3. The electromagnetic relay of claim **2** wherein the spring-based aperture means for enhancing spring over travel provide means for contact wiping, said contact wiping means for cleansing the switch terminals.

4. The electromagnetic relay of claim **1** comprising spring-based aperture means for damping contact vibration intermediate the first and second contacts when switching from the open contact position to the closed contact position.

5. The electromagnetic relay of claim **1** comprising bridge-mounting means, the bridge-mounting means for enabling open face operation of the electromagnetic relay.

6. The electromagnetic relay of claim **1** comprising means for defaulting to a closed contact position during fault current conditions.

7. The electromagnetic relay of claim **1** comprising means for defaulting to an open contact position during threshold terminal-based current conditions.

8. An electromagnetic relay, the electromagnetic relay for enabling current to pass through switch termini, the electromagnetic relay comprising:

a coil assembly, the coil assembly comprising a coil, a coil axis, and a C-shaped core, the coil being wound round the coil axis, the coil axis extending through the core, the core comprising core termini, the core termini being parallel to the coil axis;

a bridge assembly, the bridge assembly comprising an axis of rotation, a bridge, and opposing actuators, the bridge comprising a medial field pathway, a zigzagged lateral field pathway, and spaced transverse field pathways, the actuators extending from terminal portions of the lateral field pathway, the core termini being coplanar with the axis of rotation and received intermediate the medial and lateral field pathways; and

first and second switch assemblies cooperable with the actuators, the coil for creating a magnetic field, the magnetic field being directable through the bridge assembly via the core termini for imparting bridge rotation about the axis of rotation via magnetically induced torque, the bridge rotation for displacing the actuators, the displaceable actuators for opening and closing the switch assemblies, the closed switch assemblies for enabling current to pass therethrough.

9. The electromagnetic relay of claim **8** wherein the switch assemblies comprise spring-based aperture over travel means for enhancing spring over travel and for enhancing the closed switch position.

10. The electromagnetic relay of claim **9** wherein the spring-based aperture over travel means provide contact wiping means, said contact wiping means for cleansing the switch assemblies.

11. The electromagnetic relay of claim **8** comprising spring-based aperture damping means for damping switch vibration when switching from open to closed switch positions.

12. The electromagnetic relay of claim **8** comprising bridge-mounting means, the bridge-mounting means for enabling open face operation of the electromagnetic relay.

13. The electromagnetic relay of claim **8** comprising means for defaulting to a closed contact position during fault current conditions.

14. The electromagnetic relay of claim **8** comprising means for defaulting to an open contact position during threshold terminal-based current conditions.

15. The electromagnetic relay of claim **9** wherein the switch assemblies each comprise a spring assembly, the spring assemblies each comprising three spring elements, a first of the three spring elements comprising a first C-shaped aperture, the first C-shaped aperture defining a first semi-circular aperture-defining extension, the first C-shaped aperture being concentric about the first contact-receiving aperture, a second of the three spring elements comprising a second contact-receiving aperture and terminating in a second semi-circular aperture-defining extension, a third of the three spring elements comprising a third contact-receiving aperture, and a second C-shaped aperture, the second C-shaped aperture defining a third semi-circular aperture-defining extension, the second C-shaped aperture being concentric about the second contact-receiving aperture, the first and second C-shaped apertures being symmetrical about the longitudinal axes of the first and third spring elements, the second spring being sandwiched intermediate the first and third spring elements via the second contact such that the first, second and third semi-circular aperture-defining extensions are uniformly stacked, the three spring elements so configure providing the spring-based aperture means for enhancing spring over travel.

16. The electromagnetic relay of claim **11** wherein the switch assemblies each comprise a spring assembly, the spring assemblies each comprising three spring elements, a first of the three spring elements comprising a first C-shaped aperture, the first C-shaped aperture defining a first semi-circular aperture-defining extension, the first C-shaped aperture being concentric about the first contact-receiving aperture, a second of the three spring elements comprising a second contact-receiving aperture and terminating in a second semi-circular aperture-defining extension, a third of the three spring elements comprising a third contact-receiving aperture, and a second C-shaped aperture, the second C-shaped aperture defining a third semi-circular aperture-defining extension, the second C-shaped aperture being concentric about the second contact-receiving aperture, the first and second C-shaped apertures being symmetrical about the longitudinal axes of the first and third spring elements, the second spring being sandwiched intermediate the first and third spring elements via the second contact such that the first, second and third semi-circular aperture-defining extensions are uniformly stacked, the three spring elements so configured providing the spring-based aperture means for damping contact vibration.

17. An electromagnetic relay, the electromagnetic relay for enabling current to pass through switch termini, the electromagnetic relay comprising:

a coil assembly, the coil assembly for selectively creating a coil-emanating magnetic field;

a rotatable bridge assembly, the bridge assembly comprising opposing switch actuators and a bridge-based magnetic field; and

first and second switch assemblies cooperable with the switch actuators, the coil-emanating magnetic field being directable through the bridge assembly for imparting bridge rotation via the bridge-based magnetic field, the bridge rotation for displacing the switch actuators about a bridge axis of rotation, the displaceable switch actuators for opening and closing the switch assemblies, the closed switch assemblies for enabling current to pass therethrough;

wherein the switch assemblies comprise spring-based aperture over travel means for enhancing spring over travel and for enhancing the closed switch position; wherein the switch assemblies each comprise a spring assembly, the spring assemblies each comprising three spring elements, a first of the three spring elements comprising a first C-shaped aperture, the first C-shaped aperture defining a first semi-circular aperture-defining extension, the first C-shaped aperture being concentric about the first contact-receiving aperture, a second of the three spring elements comprising a second contact-receiving aperture and terminating in a second semi-circular aperture-defining extension, a third of the three spring elements comprising a third contact-receiving aperture, and a second C-shaped aperture, the second C-shaped aperture defining a third semi-circular aperture-defining extension, the second C-shaped aperture being concentric about the second contact-receiving aperture, the first and second C-shaped apertures being symmetrical about the longitudinal axes of the first and third spring elements, the second spring being sandwiched intermediate the first and third spring elements via the second contact such that the first, second and third semi-circular aperture-defining extensions are uniformly stacked, the three spring elements so configured providing the spring-based aperture means for enhancing spring over travel.

18. An electromagnetic relay, the electromagnetic relay for enabling current to pass through switch termini, the electromagnetic relay comprising:

a coil assembly, the coil assembly for selectively creating a coil-emanating magnetic field; a rotatable bridge assembly, the bridge assembly comprising opposing switch actuators and a bridge-based magnetic field; and first and second switch assemblies cooperable with the switch actuators, the coil-emanating magnetic field being directable through the bridge assembly for imparting bridge rotation via the bridge-based magnetic field, the bridge rotation for displacing the switch actuators about a bridge axis of rotation, the displaceable switch actuators for opening and closing the switch assemblies, the closed switch assemblies for enabling current to pass therethrough; and spring-based aperture damping means for damping switch vibration when switching from open to closed switch positions;

wherein the switch assemblies each comprise a spring assembly, the spring assemblies each comprising three spring elements, a first of the three spring elements comprising a first C-shaped aperture, the first C-shaped aperture defining a first semi-circular aperture-defining extension, the first C-shaped aperture being concentric about the first contact-receiving aperture, a second of the three spring elements comprising a second contact-receiving aperture and terminating in a second semi-circular aperture-defining extension, a third of the three spring elements comprising a third contact-receiving aperture, and a second C-shaped aperture, the second C-shaped aperture defining a third semi-circular aperture-defining extension, the second C-shaped aperture being concentric about the second contact-receiving aperture, the first and second C-shaped apertures being symmetrical about the longitudinal axes of the first and third spring elements, the second spring being sandwiched intermediate the first and third spring elements via the second contact such that the first, second and third semi-circular aperture-defining extensions are uniformly stacked, the three spring elements so configured providing the spring-based aperture means for damping contact vibration.

19. An electromagnetic relay, the electromagnetic relay for enabling current to pass through switch termini, the electromagnetic relay comprising:

a coil assembly, the coil assembly comprising a current-conductive coil and a coil axis, the coil for creating a magnetic field;

an armature assembly, the armature assembly comprising switch actuators, a zigzagged rotor bracket having opposing actuator-engaging structures, and field-diversion means, the field-diversion means for transversely diverting the magnetic field relative to the coil axis and magnetically inducing a torque, the magnetically induced torque for actuating the switch actuators via the actuator-engaging structures; and

first and second switch assemblies, the switch actuators being cooperable with the switch assemblies for enabling current to pass therethrough, wherein the first and second switch assemblies each comprising spring-based aperture, means for damping switch vibration when switching from open to closed switch positions; wherein each switch assembly comprises a spring assembly, the spring assemblies each comprising three spring elements, a first of the three spring elements comprising a first C-shaped aperture, the first C-shaped aperture defining a first semi-circular aperture-defining extension, the first C-shaped aperture being concentric about the first contact-receiving aperture, a second of the three spring elements comprising a second contact-receiving aperture and terminating in a second semi-circular aperture-defining extension, a third of the three spring elements comprising a third contact-receiving aperture, and a second C-shaped aperture, the second C-shaped aperture defining a third semi-circular aperture-defining extension, the second C-shaped aperture being concentric about the second contact-receiving aperture, the first and second C-shaped apertures being symmetrical about the longitudinal axes of the first and third spring elements, the second spring being sandwiched intermediate the first and third spring elements via the second contact such that the first, second and third semi-circular aperture-defining extensions are uniformly stacked, the three spring elements so configured providing the spring-based aperture means for damping contact vibration.

20. The electromagnetic relay of claim **2** wherein the switch assemblies each comprise a spring assembly, the spring assemblies each comprising three spring elements, a first of the three spring elements comprising a first C-shaped aperture, the first C-shaped aperture defining a first semi-circular aperture-defining extension, the first C-shaped aperture being concentric about the first contact-receiving aperture, a second of the three spring elements comprising a second contact-receiving aperture and terminating in a second semi-circular aperture-defining extension, a third of the three spring elements comprising a third contact-receiving aperture, and a second C-shaped aperture, the second C-shaped aperture defining a third semi-circular aperture-defining extension, the second C-shaped aperture being concentric about the second contact-receiving aperture, the first and second C-shaped apertures being symmetrical about the longitudinal axes of the first and third spring elements, the second spring being sandwiched intermediate the first and third spring elements via the second contact such tat the first, second and third semi-circular aperture-defining extensions are uniformly stacked, the three spring elements so configured providing the spring-based aperture means for enhancing spring over travel.

21. The electromagnetic relay of claim **4** wherein the switch assemblies each comprise a spring assembly, the spring assemblies each comprising three spring elements, a first of the three spring elements comprising a first C-shaped aperture, the first C-shaped aperture defining a first semi-circular aperture-defining extension, the first C-shaped aperture being concentric about the first contact-receiving aperture, a second of die three spring elements comprising a second contact-receiving aperture and terminating in a second semi-circular aperture-defining extension, a third of the three spring elements comprising a third contact-receiving aperture, and a second C-shaped aperture, the second C-shaped aperture defining a third semi-circular aperture-defining extension, the second C-shaped aperture being concentric about the second contact-receiving aperture, the first and second C-shaped apertures being symmetrical about the longitudinal axes of the first and third spring elements, the second spring being sandwiched intermediate the first and third spring elements via the second contact such that the first, second and third semi-circular aperture-defining extensions are uniformly stacked, the three spring elements so configured providing the spring-based aperture means for damping contact vibration.

22. The electromagnetic relay of claim **1** wherein the actuator arms simultaneously and respectively pull-close and push-close the switch assemblies for enabling current to pass therethrough.

23. The electromagnetic relay of claim **8** wherein the actuator arms simultaneously and respectively pull-close and push-close the switch assemblies for enabling current to pass therethrough.

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